

# NATIONAL GEOGRAPHIC



# After Oil

## Powering the Future

**THE BOMB—60 Years Later** 98

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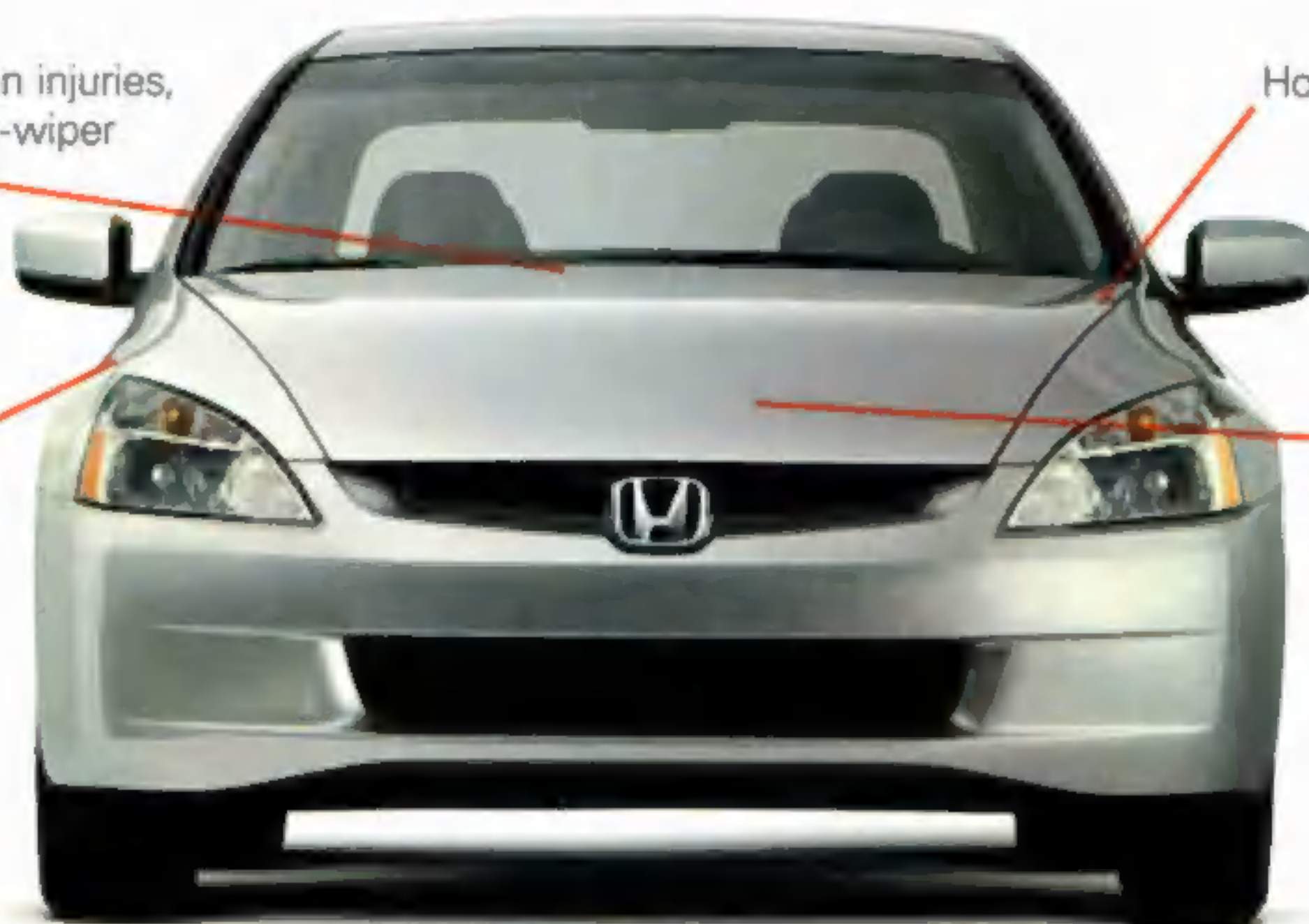
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# Every car company is concerned about safety inside its cars. But what about safety outside its cars?

To help reduce pedestrian injuries, the modified windshield-wiper system helps absorb energy in the event of an accident.

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Created by Honda engineers, POLAR II is the most advanced pedestrian test dummy, and simulates the kinematics of the human body.

created POLAR II, a unique

[safety.honda.com](http://safety.honda.com)

Based on Traffic Safety Facts 2003 from NHTSA. 2005 Accord EX Sedan shown. ©2005 American Honda Motor Co., Inc.



# Concerned about the people about the people outside?

pedestrian test dummy with sensors that help analyze the types of injuries that could be sustained in an accident.

Our pioneering research has led to the development of a number of pedestrian-protection features, including injury-reducing designs that minimize direct contact with the most rigid part of the vehicle. More than 2 million U.S. Honda and Acura vehicles on the road today have this equipment. Honda is dedicated to advancing our safety technologies, with our goal of “Safety for Everyone” leading the way.



POLAR II has instruments that measure the level of injury throughout the body, including the head, neck, chest, abdomen and legs.

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**Health**

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**Lifestyle**

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**Communication**

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**Transportation**


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**Building**



Living.  
Improved daily.™





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### THE COVER

Vintage gas pumps in California foretell a future without oil.

BY SARAH LEEN

♻️ Cover printed on recycled-content paper

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CONCENTRATED SUNLIGHT PERCED THE SLITCH HELD BY ENGINEER CARL BINGHAM. PHOTO: SARAH LEEN


**H**istory is propelled by decisions made to accommodate the present but with unforeseen consequences for the future. Winston Churchill made one of those decisions on the eve of World War I. Then First Lord of the Admiralty, he took a “fateful plunge” and boldly ordered that the ships of the Royal Navy be fueled by imported oil instead of domestic coal. Their greater speed, he predicted, would add “a new element into naval war.”

Oil, of course, also added a new element to world politics. What would the world look like today if the West were not dependent on imported oil? Would the United States and other countries have 160,000 troops in Iraq? Would we be debating whether or not to drill for oil in the Arctic National Wildlife Refuge?

The prospect of a similar turning point resonates through this month’s lead story, “Future Power.” To carry the questioning forward, what would happen if we decided to convert from fossil fuels to alternative sources of energy? What would it cost? How would we benefit? How viable is any of this? Is it even possible to fuel the complex engines of today with alternative sources like wind, solar, and biomass?

The answers to these questions still elude us, but at NATIONAL GEOGRAPHIC we’ll never stop trying to find them. We’ll continue to present such discussions in the magazine and give voice to leading thinkers and doers, who, like Churchill, have the intelligence and courage to make decisions that profoundly affect history.




A pileated woodpecker with its characteristic red crest and black and white body is perched on a black cordless drill battery. The battery has a red label with "18V" and "Li-Ion" visible. The background is a warm, golden-yellow gradient with a blurred image of a cordless drill.

Protect his habitat. And yours.

What does a pileated woodpecker and a cordless drill battery have in common? When you recycle your rechargeable batteries, you preserve his environment — and ours. Check the batteries in your other cordless power tools, as well as laptop computers, cordless and cell phones, PDAs, camcorders, and remote control toys. If they no longer hold a charge, recycle them by visiting [www.rbrc.org](http://www.rbrc.org), calling **1-800-8-BATTERY**, or dropping them off at one of these national retailers.

RBRC was named "Environmental Partner of the Year" by The Home Depot in 2002.

**Recycle your rechargeable batteries.**

Richard Karn, known as "Al" from the TV show Home Improvement, is shown from the waist up. He is wearing a blue button-down shirt with a logo on the left chest and khaki pants. He is smiling and holding several power tools, including a yellow and black circular saw, a cordless drill, and a reciprocating saw.

RBRC Spokesperson Richard Karn,  
"Al" from TV's *Home Improvement*



Drop off your rechargeable batteries at the following national retailers:

**In the US:**

Best Buy  
Black & Decker  
Cingular Wireless  
The Home Depot  
RadioShack  
Staples  
Target

**In Canada:**

Bell Mobility  
Canadian Tire  
Future Shop  
The Home Depot  
RadioShack  
The Sony Store  
TELUS Mobility



# OnScreen & Online



NATIONAL GEOGRAPHIC  
CHANNEL



AUGUST 21 & 22, 9 P.M. ET/PT

**Inside 9/11** It's the definitive story of what happened before, during, and after the deadliest terrorist attack ever on U.S. soil. New research brings the story up to date for the first time on television. This important four-part series traces the movements of the al Qaeda attackers, exploring their motives and training, and examines why authorities around the world missed the danger signals. You'll learn about recent government findings and see exclusive interviews with terrorist informants and survivors of the September 11, 2001, attacks on the World Trade Center and the Pentagon.



SUNDAYS AT 8 P.M. ET/PT  
**EXPLORER**

Hurricanes, tsunamis, earthquakes: Is our planet getting more dangerous? What can we do to protect ourselves? *Explorer*, with host Lisa Ling, investigates these destructive forces and brings you the answers.

Also this month *Explorer* takes you behind the walls of one of the toughest maximum security prisons in California. You'll meet Kevin and Oliver, two inmates about to enter this brutal world, and find out their plans for survival.

Insightful interviews, amazing footage, and smart reporting define each episode of National Geographic Channel's award-winning series. *Explorer* gives you a view of the world you won't discover anywhere else.

Find out what's on and how to get the Channel in your area at [nationalgeographic.com/channel](http://nationalgeographic.com/channel). Programming information is accurate at press time. Consult local listings.

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■ **ENTER TODAY** and find official rules at [nationalgeographic.com/grandcanyon](http://nationalgeographic.com/grandcanyon).

**LIVING WITH THE BOMB** Video Witness a 1946 atomic bomb blast on Bikini Atoll. Then join our online forum to weigh in on how you feel the bomb has shaped modern life.

■ **NGM STORIES IN THE NEWS** Check in with NGM to find full-text articles of select stories that have made the headlines at [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508).

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# Behind the Scenes



## INDIA'S UNTOUCHABLES

### Help From Afar

Peggy Penrod's extraordinary story began in an ordinary way. Flipping through the June 2003 GEOGRAPHIC at her doctor's office, the Ohio woman saw the photograph of Ramprasad, an Indian man with serious burns from acid thrown by upper caste villagers. "What got my attention was the left side of his face that was OK," said Peggy. "There was such pain there." Determined to help, Peggy sold candles and collected donations, eventually gathering \$12,000. She found allies in India in burn specialist Dr. P. K. Bilwani and consultant Neha Vasant-Diddee, who donated services. Ramprasad doesn't say much. Yet several 36-hour train rides to the hospital, an artificial eye and ear, and many surgeries later, his progress is apparent (above). More surgery is scheduled. But Peggy, who plans to meet Ramprasad and Dr. Bilwani in India this fall, notices a change already. "Isn't it great to see him smiling?" To help, write to the Gathering Place, Attn: Ramprasad Fund, 120 W. Court St., Washington Court House, OH 43160-0092.

## FILM

### Penguin Tales

French filmmaker Luc Jacquet went to Antarctica to shoot a story of love and adventure—starring emperor penguins. "I was moved by their will to live," said Jacquet, who spent 13 months on location exploring penguin couples' devotion to each other even as they spend much of the year apart. A female may waddle more than a hundred miles to the sea to find food for her young; a male might lose half his body weight while warming their egg and waiting for her return. Yet filming wasn't always dramatic. Sometimes it was comical. Certain lonely penguins, explains Jacquet, "tried to seduce the film crew." Singing and flirting, the birds "were so enamored they wouldn't go away." A National Geographic Feature Films and Warner Independent Pictures movie, *March of the Penguins* opened in wide release in the U.S. in July.



## Calendar

### Special Edition Print offer.

Put a Mars rover on your wall. This 24-by-20-inch print is available until August 31. To order, call 1-800-621-0723 (or 1-813-979-6845 outside the U.S. and Canada) or go to [nationalgeographic.com/magazine](http://nationalgeographic.com/magazine).

### JULY

#### 15 National Geographic Live!

Chicago fall series. Get tickets for upcoming speakers at The Field Museum in Chicago. Call 312-665-7400.

### AUGUST

#### 15 "Africa Megaflyover"

exhibit opens. Follow the trail of Mike Fay's aerial survey of Africa, and see images from the epic journey. National Geographic, Washington, D.C.

#### 21, 22 Inside 9/11

on the National Geographic Channel. Investigate the events that unfolded before, during, and after the fateful day. The four-part series airs August 21 and 22, 9 p.m. ET/PT.

### SEPTEMBER

#### 22-25 All Roads Film Festival

Enjoy work by an international group of indigenous and minority culture filmmakers, photographers, and artists. Egyptian Theatre, Los Angeles.

#### 28 "Napoleon: An Intimate

Portrait" exhibit. Learn about Napoleon's life—from obscurity to glory to exile—and view his treasured personal possessions. National Geographic Museum, Washington, D.C.

Calendar dates are accurate at press time; please visit [nationalgeographic.com](http://nationalgeographic.com) or call 1-800-NGS-LINE (647-5463) for more information.



THROUGH A PHOTOGRAPHER'S EYE

# Visions of Earth

## ISLAND OF MAURITIUS

**Green leaf platters** on a quiet pond, these giant Amazonian water lilies at first seemed perfectly suited to the old botanical garden at Pamplémousses, laid out in the 1700s as a manicured French estate. But when the sun suddenly backlit the leaves, the lilies' wilder side shone through. Hidden jungle patterns and vibrant colors exploded. I've often found that I have to sit back and wait for a scene's secrets to reveal themselves. —David Lyons

► Decorate your desktop with these illuminated lily pads, in Fun Stuff at [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508).

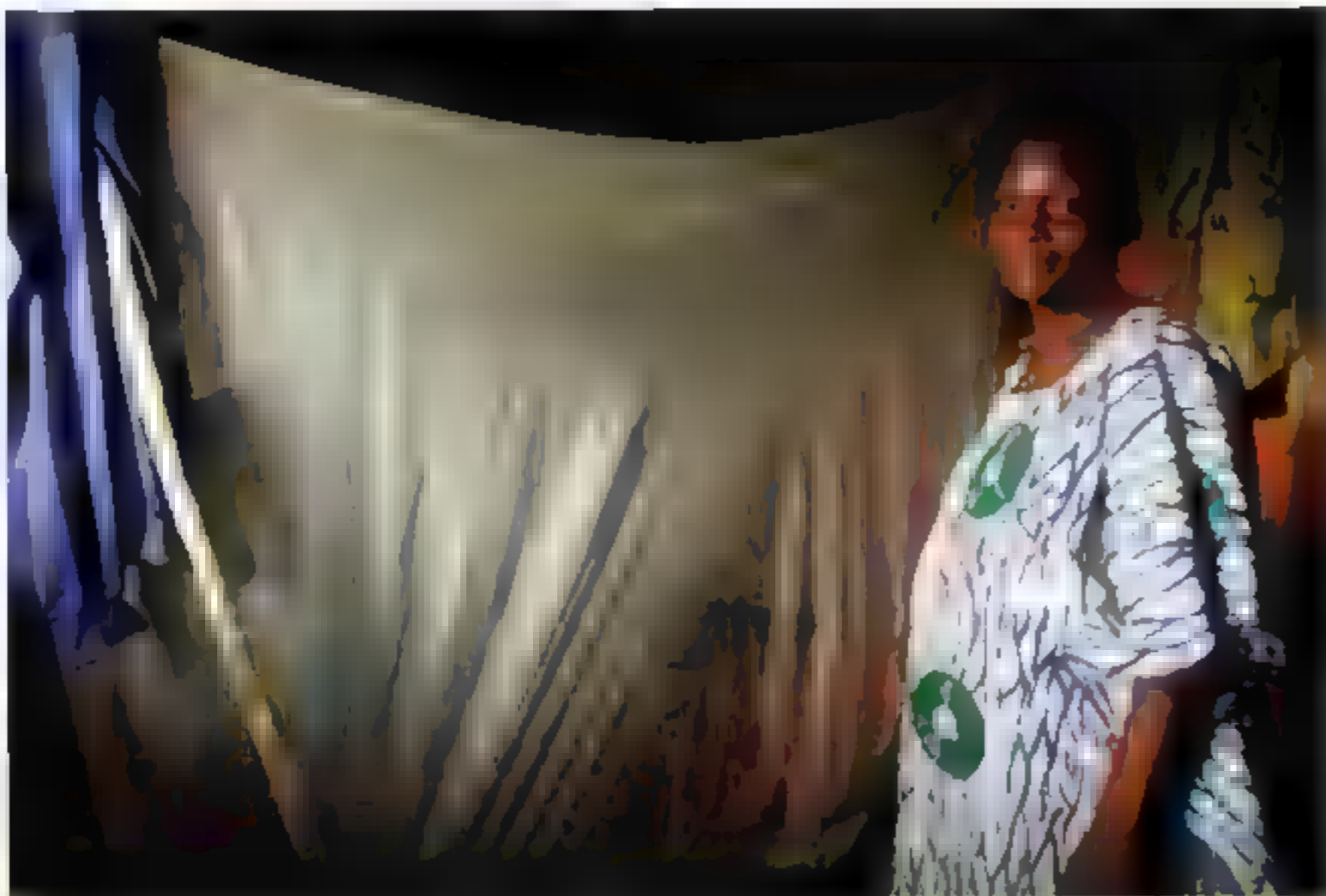






# PROTECTING COMMUNITIES WITH LIFESAVING KNOWLEDGE

GlaxoSmithKline helps Africa's Most Vulnerable Fight Malaria



## Preventable Tragedy

Malaria strikes 500 million people each year—with most deaths occurring among sub-Saharan Africa's vulnerable young children and pregnant women. It is estimated that an African child dies of malaria every 30 seconds. Even more shocking when you consider just how easily malaria can be prevented and treated. Lack of awareness and limited resources make it difficult for people to protect themselves and their families from infection.

## Crucial Connections

GlaxoSmithKline (GSK) partnerships with AMREF (the African Medical and Research Foundation), Plan International, and Freedom from Hunger work with affected communities to raise awareness of how to prevent infection and access effective treatment. Simple measures, such as insecticide-treated bednets, treatment during pregnancy, and learning to recognize the early signs of malaria fevers in young children are proving lifesaving. But this is not enough, and GSK is committed to public-private research partnerships to develop new malaria medicines and a vaccine, so that one day malaria might be a disease of the past.



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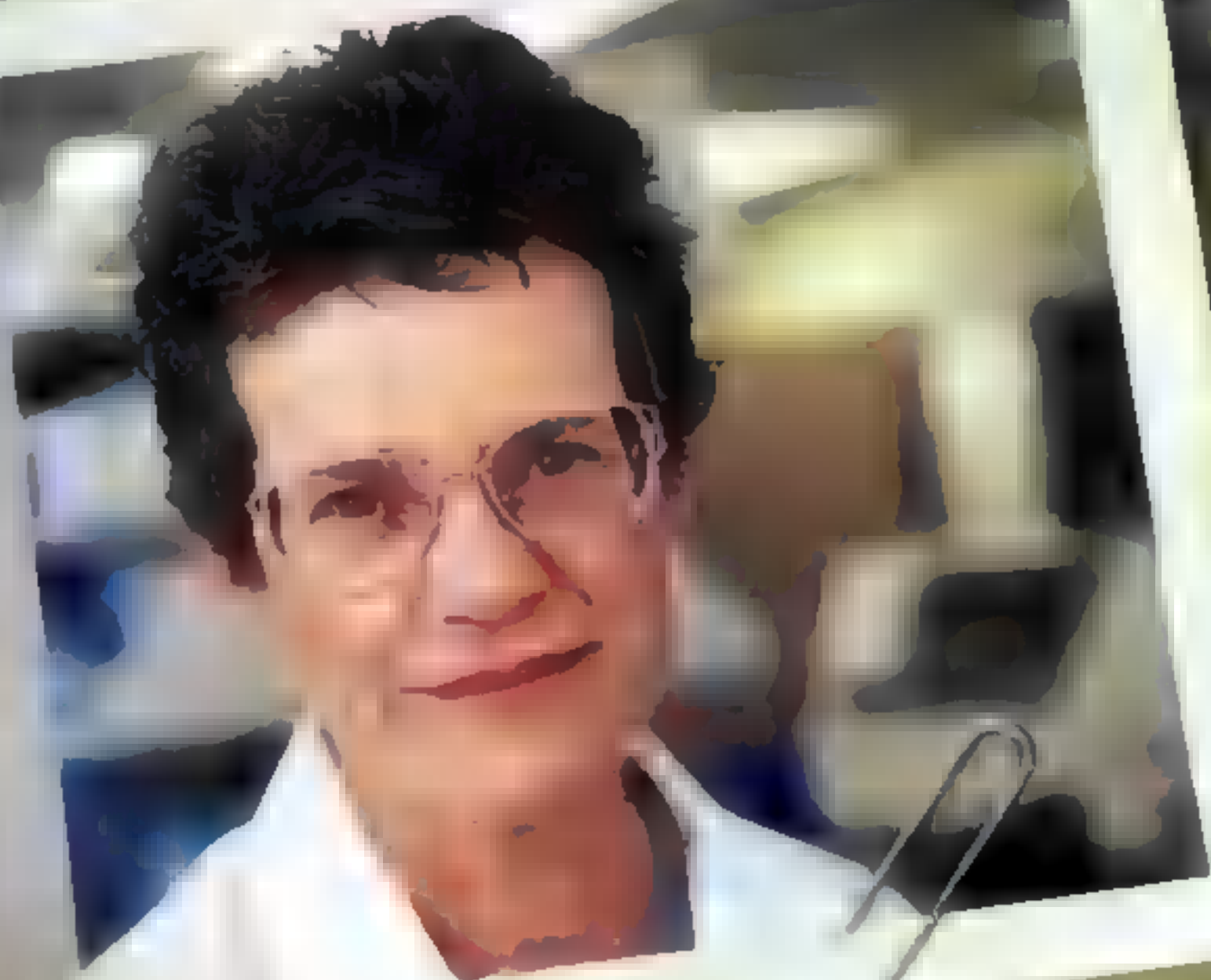
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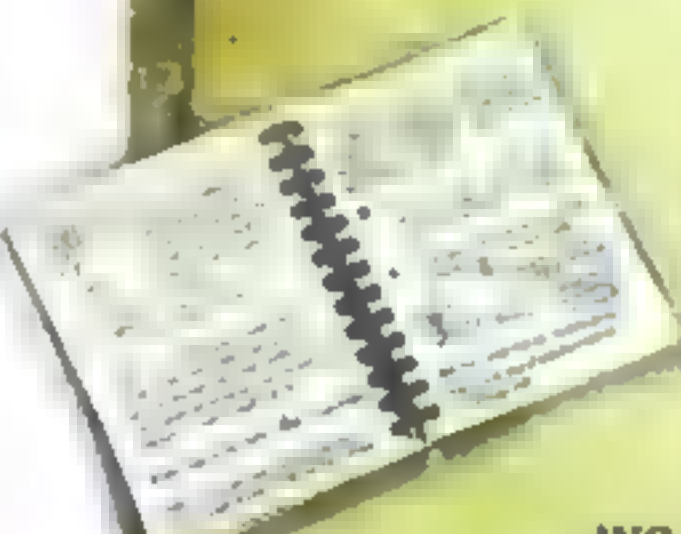
For additional information go to [www.gsk.com/community](http://www.gsk.com/community).





AFTER 20 YEARS OF HARD WORK WE'VE ALMOST  
**ELIMINATED PEDIATRIC HIV**

ALMOST ISN'T GOOD ENOUGH



When we started working on HIV two decades ago, we had no idea what we were up against. Even with thousands of scientists using the world's most advanced technology, it still takes about 15 years and \$800 million



just to develop one new drug. HIV requires several. Some people say drug research is too expensive, but when you consider our astounding accomplishments with pediatric HIV, and all the children we've helped to save, it's worth it.



Today's medicines. Tomorrow's miracles.<sup>SM</sup>



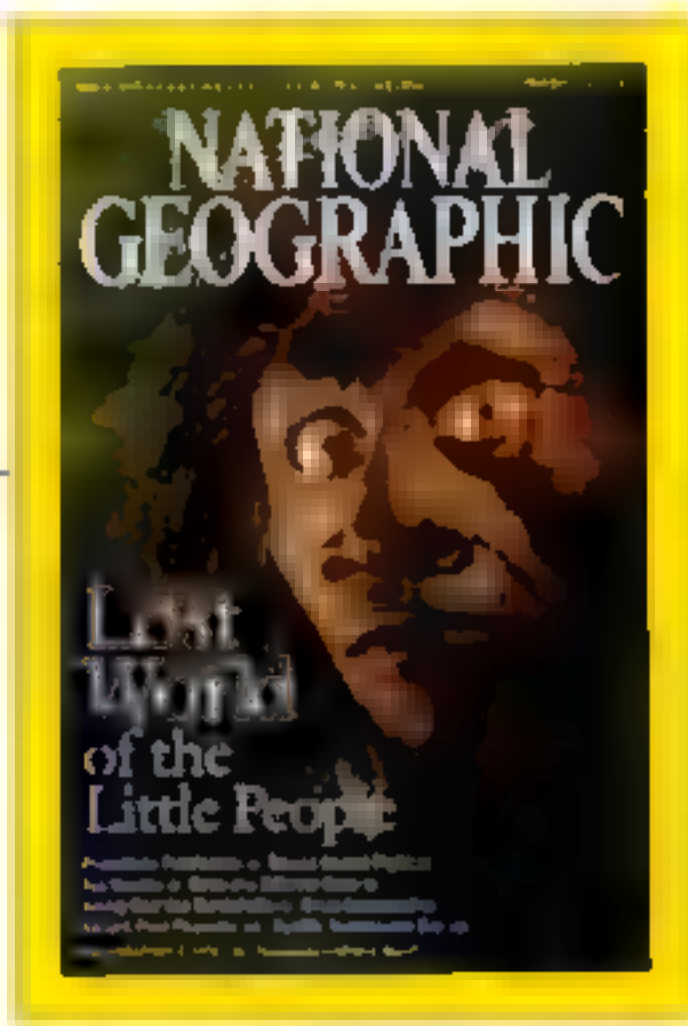
GlaxoSmithKline



# Forum

## April 2005

"Hallowed Ground," a look at the state of Civil War battlefields, and the articles on early humans, "World of the Little People" and "The Pathfinders," generated an abundance of mail. "ZipUSA: Guantanamo Bay" received spirited letters about whether the base should exist at all and about the treatment of its newest inhabitants—prisoners from the war on terror.



## Hallowed Ground

I hope the article on Civil War battlefields awakened a reverence in readers. These fields of death cannot fade from memory. They are too important, too humbling, and too full of the blood that built our nation. In our modern world of strip malls and fast food, the grand epic of humanity is being obliterated by instant material gratification. We are so quick to forget, and, as this article showed, our history is agonizingly fragile.

LUKE WALKER  
Fort Wayne, Indiana

I'm all for parks and open spaces, but I am opposed to restoring more land to commemorate those occasions—no matter how noble or glorious—when the principal activity was men killing other men. The car lots, the housing developments, and the pizza places may not be that

attractive, but they represent people's efforts for a better life, and I'll choose them any day over a memorial to a blood-stained field.

WAYNE B. DIXON  
Gettysburg, Pennsylvania

You state that many argue about the war's causes, yet you present only that it was "a struggle over slavery and freedom." While this is currently the popular view, it was not the opinion of most people of that time, including Abraham Lincoln, who wanted to preserve the Union at all costs. Except by a few abolitionists, slavery was not under attack at the beginning of the war. The men of the South, most of whom owned no slaves, were fighting to defend what they considered to be their sovereign country against an invading army.

H. PARKS TILLY  
Fayetteville, Texas

Kudos to Adam Goodheart for correctly placing the Civil War in the context of slavery. Apologists who wish to paint the Confederacy as engaged in a noble lost cause will doubtless assert that states' rights was the real issue of the war, citing Lincoln's primary objective of preserving the Union. But while the North

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IT HAS ROOM FOR EVERYTHING  
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### ZipUSA: Guantanamo Bay

Thank you for portraying Guantanamo Bay as an actual place instead of an abstract and impersonal idea. As writer Jeannie Ralston asserts, the U.S. government allowed reporters to see only what they designated so as not to create negative publicity. However Ralston, rather than focusing on the information gaps and consequently joining the journalistic bandwagon, interjects her story with experiences of the individuals who are most closely tied to the base. This inclusion of emotions helps connect readers to those at Guantanamo Bay.

KATE PIWONSKI  
Northfield, Connecticut

Since when does America hold prisoners without trials? The administration claims prisoners are not tortured. The men were bound up on planes like animals, flown thousands of miles to a hellhole prison, then subjected to brutal interrogations. How can we claim to be a beacon of freedom while this blatant disregard for human rights continues?

PAUL N. CARRON  
Green Bay, Wisconsin

The tone of the article seems to reflect a grudging approval of prisoner treatment, but it could have been much more positive. We treat these people who are ready, willing, and able to kill us with more respect than they deserve and certainly far better than they treat their prisoners.

JOHN DERR  
Port Charlotte, Florida

Thank you for drawing attention to the huge waste of money at Guantanamo Bay. We spend 162 million dollars a year there just to pump up our egos. Let's give the land back to Cuba.

PAUL OLSON  
Breckenridge, Colorado

didn't necessarily enter the war in order to abolish slavery, the South did so in order to preserve it. The tragedy of the Civil War was that hundreds of thousands of people need not have died if only the vested interests of slaveholders had not been put before those of the nation.

ARTHUR O'KEEFE  
Ayase, Japan

### The Pathfinders

Your article presents the argument that cooperation and caregiving had evolved in *Homo*

*erectus* some 1.7 million years ago. The primary evidence for this is the extreme tooth loss seen in the hominin fossil Dmanisi D3444. However, data from nonhuman primates clearly illustrate that individuals can survive for years with worn, damaged, and missing teeth, without the aid of other individuals or stone tools. These data come from field studies of living primates, as well as analysis of skeletal specimens housed in museums and research centers.

FRANK P. CUOZZO  
University of North Dakota, Grand Forks  
MICHELLE L. SAUTHER  
University of Colorado, Boulder

### World of the Little People

The discovery of *Homo floresiensis* is one of the most important discoveries of recent history. It should serve as a reminder that

we have not yet learned all there is to learn about our genesis.

PETER JOHN GETTY  
Glasgow, Scotland

FROM OUR ONLINE FORUM  
[nationalgeographic.com/magazine/0504](http://nationalgeographic.com/magazine/0504)

Reading your article on the discovery of tiny hominins reminded me of folk legends that exist in the Hawaiian Islands about the little menhune people who supposedly predated the Hawaiians. Perhaps there's a basis for those legends after all.

LARRY SULKIS  
Los Angeles, California

*The menhune, like the leprechauns of Ireland, are mythical creatures. Many readers wondered whether future research will discover that folklore about little people—from India, northern Europe, and Hawaii—is based on fact.*

**WRITE TO FORUM** National Geographic Magazine, PO Box 98199, Washington, DC 20090-8199, ■ by fax to 202-828-5460, or via the Internet to [ngsforum@nationalgeographic.com](mailto:ngsforum@nationalgeographic.com). Include name, address, and daytime telephone. Letters may be edited for clarity and length.





**Golden Takin** (*Budorcas taxicolor*)

**Size:** Head and body length, 100-237 cm, shoulder height, 68-140 cm, tail, 7-12 cm **Weight:** 150-400 kg

**Habitat:** Forested valleys to rocky, grass-covered alpine zones at altitudes of 1,000-4,500 m in Qinling, China

**Surviving Number:** Estimated at 1,200



*Photographed by Zhuang Li*

# WILDLIFE AS CANON SEES IT

One cough and they're off. A cough warning of approaching danger is one of two primary vocalizations in the golden takin's repertoire. The other is a low bellow used during mating season. Males and females—both of which grow horns—travel together in small herds, browsing on bamboo, fir bark and fresh shrub branches. Salt adds important minerals to their diet, and they will spend days traveling to salt licks and days more taking

in their fill. But their journeys are becoming more treacherous all the time: increasingly fragmented herds are prey to poaching as well as deforestation. Some dangers just can't be avoided with a cough.

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Only purchases made with a MasterCard that is in good standing (both at time of entry & winner selection) & processed by MasterCard member financial institution in the U.S. & that is processed & submitted through MasterCard International Incorporated's U.S. transaction processing system during the Promotion Period are eligible for automatic entry, or 4) To enter the Sweepstakes without using a MasterCard & receive (4) entries, hand print your complete mailing address, telephone number & birth on a plain 3" x 5" piece of paper & mail it in a manila envelope to MasterCard Win 12 Cars Sweepstakes, P.O. Box 15124, Bridgeport, CT 06673-5124. Enter as often as you wish by mail, but each entry must be mailed separately & received by 9/22/05. No photocopied, computer generated facsimiles, mechanically reproduced, or mass entries permitted. Your use of your MasterCard to make a purchase &/or your submission of a 3" x 5" mail-in entry constitutes your consent to participate in this Sweepstakes & your consent for Sponsor to obtain, use & transfer your name, address & other information for the purpose of administering this Sweepstakes. Released Parties are not responsible for lost, incomplete, illegible, late, misdirected, stolen, postage-due, mutilated entries or mail any error omission interruption, defect or delay in transmission, 3rd party transaction classification, transaction processing or communication, technical or mechanical malfunctions, failures or malfunctions of phones, phone lines, telephone systems, errors in these Official Rules, in any Sweepstakes-related advertisements or other materials, failures of electronic equipment, computer hardware or software, inaccurate entry information, whether caused by equipment programming used in this Sweepstakes, human processing error, or otherwise. Sponsor reserves the right, in its discretion, to disqualify any & all entries & an entrant who Sponsor believes has attempted to tamper with or impair the administration, security, fairness, or proper play of this Sweepstakes. **(1) Grand Prize:** Up to a total of (12) GM cars with a maximum retail value of \$30,000 each for winner & up to (11) family members &/or friends. The GM Family of Vehicles includes Buick, Cadillac, Chevrolet, GMC, HUMMER, Pontiac, Saab, & Saturn (Maximum Approximate Retail Value "ARV"=\$360,000). **Grand Prize Transfers:** Winner must keep a minimum of (1) car for himself/herself & can transfer, without receiving compensation, any of the remaining (11) cars to a 3rd party(s) who is a legal resident of the U.S. or the District of Columbia, 18 years of age or older prior to 7/1/05 who possesses a valid U.S. driver's license ("recipient"). 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Taxes, insurance, licensing, registration, title fees, acquisition fees, destination charges, & any options not included with the car(s) as designated by Sponsor & all other expenses not specified & related to the acceptance & use of the car(s) are winner &/or recipient(s) sole responsibility. Each car will be awarded "as is" with no warranty or guarantee, either express or implied, other than warranties that may be provided by the manufacturer or dealer at their sole discretion. Prize details specifically set forth herein are at Sponsor's discretion. Federal, state & local taxes & all other expenses not specified herein are the winner's sole responsibility. **Winner Selection:** Winner will be selected in a random drawing on or about 10/20/05 from among all eligible entries received by P/S/T, an independent judging organization whose decisions will be final & binding on all matters relating to this Sweepstakes. Winner will be notified by telephone &/or mail. In the event that the potential winner is selected via a MasterCard transaction, prize will be awarded to the primary account holder (as determined by the MasterCard member financial institution's account records & subject to said financial institution's timely identification of the primary account holder) named on the account accessed by the MasterCard used to make the entry &, in the event that a corporate MasterCard winning account is selected, prize will be awarded to the individual named on the MasterCard that is used to transact the winning entry (as determined by the MasterCard member financial institution's account records & subject to the financial institution's timely identification of the account holder). If awarding of prize is in conflict with corporate written policy, not feasible after Sponsor's good faith effort to obtain account holder contact information from the applicable MasterCard member financial institution, prize will be forfeited & an alternate winner may be selected. Odds of winning will depend on the number of eligible entries received. **Miscellaneous:** Except as set forth above, no transfer, assignment, cash redemption, or substitution of prize (or portion thereof) except by Sponsor & prize unavailability, then for a prize (or applicable portion thereof) of equal or greater value. Winner & each recipient will be required to execute & return an Affidavit of Eligibility, Liability Release (where legal), Publicity Release within (3) days of issuance of notification. Non-compliance with any of the foregoing may result in disqualification & awarding of prize to an alternate winner. If prize notification letter is returned as undeliverable, winner will be disqualified & an alternate winner may be selected. 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**Winner List:** For winner's name, send a self-addressed, stamped envelope to be received by 11/15/05 to: MasterCard Win 12 Cars Sweepstakes Winner, P.O. Box 13106, Bridgeport, CT 06673-3106. ©2005 MasterCard International Incorporated. All Rights Reserved. This Sweepstakes is not produced, sponsored or executed by General Motors Corporation. **Sponsor:** MasterCard International Incorporated, 2000 Purchase Street, Purchase, NY 10577. **Promoter:** Project Support Team, Inc., 100 Mill Plain Road, Danbury, CT 06811. www.projectsupport.com

**Flying High**

I was pleased to see your article by and about Burt Rutan and *SpaceShipOne*. Most media coverage of the events has concentrated on the "money men" and the pilots. While the financial backing was a requirement and the skill and bravery of the pilots is unquestioned, none of this would have been possible without the careful, meticulous design and manufacturing skill of Mr. Rutan and his group. Mr. Rutan has joined the Wright brothers and other pioneers and deserves more coverage than he has received. I thank you for giving him at least some.

WILLIAM STATLER

Scotia, New York

I have to admire Burt Rutan's vision and technical achievement. However, I am appalled at Richard Branson's plans for recreational space travel in view of the inevitable damage to our already threatened atmosphere by excessive terrestrial air travel. I regard the whole project as totally incompatible with the concern for climate change.

FRANK HIND

Barnstable, Devon

**Orcas Unmasked**

I'm deeply concerned about the photo on page 98, which shows my house and a commercial whale-watch boat. The boat is positioned between the whales and the shoreline and is closer to the whales than the allowable hundred-yard buffer zone. This is in violation of federal government and Whale Watch Association guidelines.

JANICE RILEY

San Juan Island, Washington

*We acknowledge that the presence of boats presents a challenge to the survival of the orcas, as mentioned on page 94. Photographer Flip Nicklin, who was with the executive director of the Center for Whale Research at the time, reports that the whale-watching boat was operating within accepted guidelines. The boat had stopped out of the path of the whales, but they changed course and swam to the outside of the boat, an action not uncommon for these whales.*

**Geographica: Tsunamis—Where Next?**

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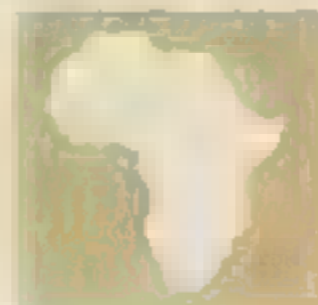
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deployed to detect tsunamis, there remains the question of evacuation. The time to evacuate can be short if the quake and resulting waves originate locally. In Southeast Asia dense populations, unreliable local communications, and poor or nonexistent roads can play havoc with the evacuation of people.

J. GORDON VAETH  
*Olympia, Washington*

I read the great articles in this issue, but I have been constantly drawn back to the satellite photos of beautiful lush greenery that was turned into brown and gray nothingness so quickly by the tsunami. How will this land ever be restored to its former beauty?

PEGGY ROBERTSON  
*Macon, Georgia*

### On Assignment

The artistry that John Gurche brings to his re-creations is stunning. Yet he does not say how he made the eyes, which were eerily genuine looking. The penetrating gaze of this tiny hominin is what brings her to life.

CATHERINE COURTEMARCHE  
*Bennington, New Hampshire*

*"The expression of apprehension in the eyes," explains John Gurche, "is almost entirely related to the soft tissue around the eyes."*

*Gurche, who got the eyes from an artificial eye company, spent four days perfecting the eyelids. What was Gurche's inspiration? He thought about how the tiny female would react to peering out at us, "a species of hominin that*

*would have seemed like holy terrors if she knew about us."*

### Visions of Earth

Never before have I seen such a stunning photo. At first glance I thought it was . . . a Cirque du Soleil costume? A magnificent carnival headdress? Something brought to life by your featured artist, John Gurche? How wonderful to discover that it was a perfect living creature, a pelican!

CORDELIA RACKLEY  
*Santa Maria, California*

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# GEOGR

THE PEOPLE, PLACES, AND



MARINE MAMMALS

## Gift From the Sea

By Peter Benchley

Twenty years ago this summer, when the movie version of my (love) *Jaws* was released, few people (including me) knew very much about great white sharks. For hundreds of years, though, we humans have been taught to fear and loathe sharks, and the movie touched a nerve of horror. *Jaws* also sparked a

facsimile with sharks that transcended this terror. In the past thirty decades a very different attitude has emerged, dedicated to preserving and protecting sharks rather than destroying them.

My own long-held thought (apparently) has happened. A great white shark was unexpectedly held in captivity for several months. In August 1973 a young female predator was caught accidentally in a fisherman's net off Huntington Beach, California, then kept in an ocean pen for 23 days. Transferred to the Monterey Bay Aquarium, she thrived in her confinement. Outer Bay (about 100 miles) from there she was too young to understand that the enormous tank was not her natural environment. Because she didn't bash her head against the walls (as attempts to swim as they do others of her kind have done). And she began to feed almost immediately on salmon offered to her on a plate. In the months that followed she didn't sustain any serious injuries, caught no diseases, and grew noticeably larger, shattering all records for great



Peter Benchley posed with this painting of a great white shark in 1974, just after his novel *Jaws* was published.



# AFRICA

CREATURES OF OUR UNIVERSE

white shark (111). The images are color-coded; white had been held was 16 days.

Scientists were interested to see what the young sharks would do to find food, and they were amazed at the diversity of food items, including the tunas, mackerels, crabs, and other sharks that were her tankmates. On February 15, then, when she bit and killed a young fish shark. As she grew larger and her behavior grew more aggressive, officials at the aquarium knew the time had come.

On March 31, after 198 days in the aquarium, the great white shark was outfitted with a transmitter and released into the Pacific. The transmitter was first received eight days after 20 days, and on May 2 it was last received 25 miles off

from Agulhas, south of Monterey. It indicated that the shark had traveled more than 100 miles offshore and gone as deep as 500 feet.

Scientists still have a lot to learn about sharks, especially great white sharks. In the best of times, they are naturally overlooked and vulnerable. We do know that sharks are critical to ocean health. Removing any significant predator from the marine food chain poses a risk of disrupting the balance of nature; remove the top predator, and the order of life in the oceans could be altered. For now, though, it's nice to think about the magnificent creature that thrived at the Monterey Bay Aquarium, paddling the waves again.





STEVE MCCURRY ABOVE; IRA BLOCK

## SEPTEMBER 11 MEMORIAL

## A Growing Remembrance

*Art takes root near ground zero*

For nearly a century, the big sycamore in the yard of St. Paul's Chapel provided leafy shade—a welcome thing in the concrete canyons of lower Manhattan. On September 11, 2001, the tree died providing protection. Uprooted during the collapse of the World Trade Center towers across the street, the sycamore fell in such a way that St. Paul's—where George Washington worshipped on his inauguration day in 1789—was shielded from the tide of the buildings' debris. Not even a window was broken in the chapel, which went on to serve for eight months as a relief ministry for ground zero's recovery workers (above).



Now, in a way, the tree will live on. Last year artist Steve Tobin, a specialist in monumental bronzes of natural forms, took the sycamore's remains back to his Pennsylvania studio (below) for casting. On September 10, 2005, those preserved remains will be returned to St. Paul's, and Tobin's 18-foot-high, 23-foot-wide bronze sculpture of the stump and roots will be permanently placed in the yard of St. Paul's parent church, Trinity, a few blocks away at Wall Street and Broadway. Donated by the artist, the work, titled "The Trinity Root," is meant as a tribute to the city and to the resilience of the people who live there.

When they see his sculpture of the sycamore's roots, says Tobin, "I'd like people to think about the fact that roots may not often be visually apparent, but that's where the tree's strength is."

—Margaret G. Zackowitz

### ST. PAUL'S AT GROUND ZERO

See more ■ the little chapel ■ [nationalgeographic.com/ngm/0209/st\\_pauls/online\\_extra.html](http://nationalgeographic.com/ngm/0209/st_pauls/online_extra.html).

## GEO NEWS

### CONSERVATION

■ **India's tigers are missing.** Poaching is suspected. Official records claim a total population of 3,642 tigers nationwide, but experts believe the true figure is much lower. Tiger populations have been dropping in India for years; the tiger count in Sariska National Park in 2002 was reported to be about 22 animals. But this year a Wildlife Institute of India team found no evidence of any tigers during a recent 15-day search of the park. Many tigers are also missing from the Ranthambore reserve, also in the state of Rajasthan. The main demand for tiger parts comes from China.

### PALEONTOLOGY

■ **A fossilized dinosaur pelvis containing two unlaidd eggs was found in China's Jiangxi Province.** The animal it once belonged to—likely a bipedal omnivore—lived more than 65 million years ago. Scientists say that its reproductive system functioned more like a bird's than a reptile's, and that it laid successive pairs of eggs, rather than a large clutch all at once.

### ANIMAL KINGDOM

■ **Butterflies' flight isn't random; they follow flight paths.** British scientists for the first time have tracked the movements of butterflies with tiny transponders attached to the insects' thoraxes. Two types of flight were found in the 30 butterflies monitored: Straight and fast flight was for travel; a slow and looping route was for orientation to aid foraging.



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## DOWN TO EARTH



EUROPEAN SPACE AGENCY

## Ice Tongue Takes Its Licks in Antarctica

Formed by the incessant push of ice off the David Glacier, the Drygalski Ice Tongue is roughly twice the length of Manhattan and juts more than 30 miles into Antarctica's Ross Sea.

"Sometimes these ice tongues

just get whacked off, but this one is so thick that it's been able to resist ocean forces," says NASA glaciologist Robert Bindschadler. Tough as it is, the Drygalski still couldn't withstand a collision with an oncoming iceberg, (top, in this

satellite image) in April—just on the tip of the tongue. Now the rest of the Drygalski—named by Antarctic pioneer Robert Falcon Scott for a fellow explorer—lives on, sticking out in cold defiance.

—Neil Shea



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# My Seven



## Where the Bones Are

**Thomas R. Holtz, Jr.** University of Maryland paleontologist, author

Tom Holtz made his first dino discovery while in grad school. Relaxing on a mound near a dig, he realized the ground was littered with fossilized eggshells. "I was sitting on a nest!" he says. He still loves fieldwork, but notes, "New insights can come from old finds in museum collections." Here are his picks for seven places to really bone up on dinosaurs.

**1 Liaoning Province, China** As long as 130 million years ago, lots of little dinosaurs lived around a lake here—and that lake is key. Rushing rivers tend to break up smaller skeletons, but here even some of the creatures' soft tissue was preserved so well that we now have evidence of feathers and other body coverings.

**2 Bahariya Oasis, Egypt** The beginning of the late Cretaceous 97 million years ago was an extreme time—hot, with high seas—for extreme animals. Giants roamed the steamy mangrove swamps: bipedal, sail-backed *Spinosaurus* and the enormous quadrupedal *Paralititan*.

**3 Alberta, Canada** Dinosaur Provincial Park has the highest overall species diversity of any dinosaur site in the world. Bone beds containing hundreds of individuals tell us that



THESE FRODDY-DINO DINOSAUR EGGS WERE FOUND IN UKHAA TOLGOD, MONGOLIA

late Cretaceous horned and duck-billed dinosaurs were herd animals.

**4 San Juan Province, Argentina** The late Triassic was the dawn of the age of dinosaurs, and Argentina's Ischigualasto formation offers a window on where they came from 230 million years ago. Some of the oldest dino remains were found here.

**5 Ukhaa Tolgod, Mongolia** Dinosaur bones can be dark due to groundwater minerals

added during fossilization, but in Mongolia's Gobi desert, fossils stayed pale—all the better to show off the spectacular preservation of a huge number and variety of late Cretaceous species.

**6 Isle of Wight, Great Britain** After 176 years of paleontological study, this site is still yielding surprises. It was home to early Cretaceous dinosaurs including *Iguanodon*. One of the earliest tyrannosaurs was also discovered here.

**7 Western U.S.** One of the best fossil sites in the United States is the Morrison formation at Dinosaur National Monument, which spans the border between Colorado and Utah. About 150 million years ago, watering holes here attracted big late Jurassic species like *Stegosaurus* and *Apatosaurus*.

**DINOSAURS COME ALIVE** See a model of *T. rex* in action, explore a dinosaur photo gallery, and find a list of related websites at [nationalgeographic.com/magazine/0303/feature1](http://nationalgeographic.com/magazine/0303/feature1).



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## Tales From the Pantanal

By Joel Sartore

**I**n theory, it's supposed to be fun—a series of photo trips to the Brazilian Pantanal for NATIONAL GEOGRAPHIC. But you have to figure that if you go repeatedly to one of the world's largest swamps, something nasty will happen.

I'm staying at a cattle ranch where tree frogs live in the toilet. The holes in my leg just might be from a flesh-eating parasite, and I've already had my assistant, Daniel De Granville (below), airlifted to the hospital for his infected head. Daniel is back and feeling better now, but there seems to be a worm in his scalp. It's only active part of the day, kicking like a baby in the womb. I offered to get us both drunk and cut it out with my pocket-knife, but he declined. We haven't even been here a week.

### The Cycle

What feels like rain at dusk is

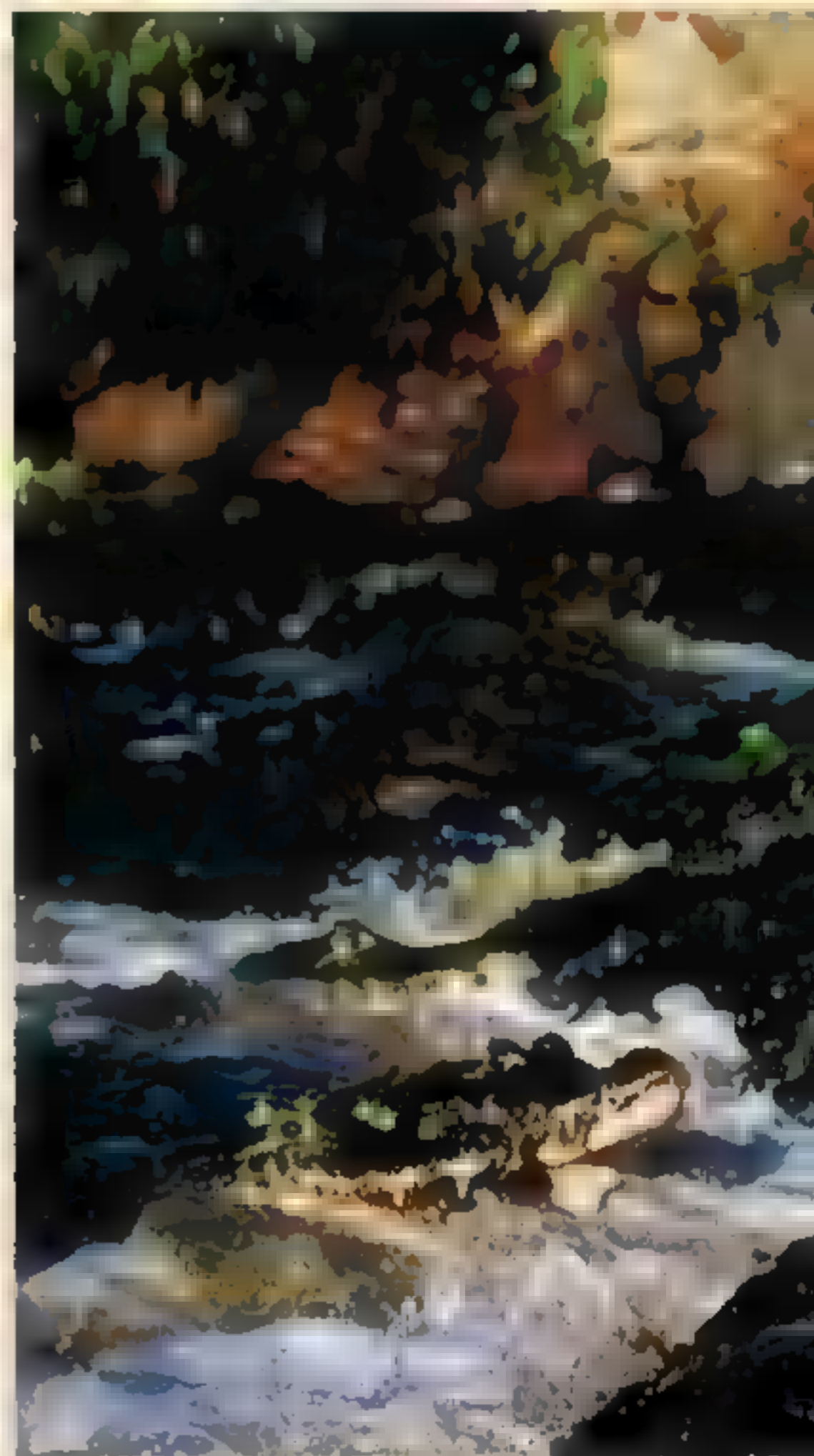
really a cloud of bugs ■ thick you can't look up. There's life in every direction. Chasing the bugs are chaotic swirls of bats, so many you can actually smell them. This whole wet place is just feeding on itself. In the Pantanal, it's life and death, all day, all night.

### The Job at Hand

I have two young kids and a pregnant wife back home in Nebraska. But I can't think about that now. It sounds terrible, but an assignment like this is a Las Vegas-quality tightrope act requiring total concentration. Make the wrong move and you're gone. So I breathe in wet air that smells like high-priced tea, and I see a marsh that is flat, wide open, and full of things to photograph.

### The Pilot

My bush pilot's nickname is Lili-que. Our plane has lots of cracks on it and in it, and always smells like it's on fire. While in flight, we have to press ■ button *on the outside of the plane* in order to make the flaps on the wings work. Not all the time. Only when we



*I wonder which of these caimans took a*

need to make turns or land.

Though he's a bit on the heavy side, Lili-que likes to wear gold chains and a really tight Speedo swimsuit when he gets in the water. But there are big piranhas everywhere here. I wouldn't want to advertise like that.

### The Otters

We're drifting downriver, and I want to stop to take a picture of giant otters. We have no anchor, of course, so I desperately grab at vines and thorny brush on the bank. The otters have guard-dog teeth and gobble fish like this Nebraskan eats fried cheese. Otters also smell bad, probably because they spend a lot of time smearing their own excrement around to mark their territory.



*Stuck in the mud, again*



# G N M E N T

C O V E R I N G T H E W O R L D



*My feet during the wet season*



*Cowboys propped up this horse.*

*bite out of my camera rig yesterday?*

They want no part of the sweaty white guy in the bow of a boat, flailing at the plants. Can't say I blame them. As it turns out, some of those plants were toxic. They caused a rash on my palms, a serious collection of dark red, burning, little geometric shapes: nine circles and one square.

### **The Signal**

As we get out of the boat, I smile and give the hand signal "OK" to the driver. My Portuguese is limited to words like "toothpick" and "water pig," so I fall back on the OK sign a lot. Then Daniel pulls me aside. "You ought to use the thumbs-up sign," he says. To a lot of old-timers, the OK sign is a vulgar gesture.

Now he tells me.

### **The Camera Traps**

My driver, whom we call Popsicle, helped me set up three camera traps in the woods. Let me give you the technical explanation: You combine a camera, flashes, and duct tape with waterproof boxes and plastic baggies and hook them all together with wires so that it looks like the big mess that it is. Then hang everything from trees and add more wires to an infrared triggering device. This machine is supposed to tell the camera when to take a picture. Unless it rains. Or it's humid. Or it's windy. Or it's sunny. Or it's not. You get the idea.


### **The Ticks**

Pantanal ticks range from the big ones that bite you so hard you

can't believe it to the tiny ones that seem to infiltrate every pore on your body just because they can. These are hard to see with the naked eye, but you know they're there; you scratch to the point of infection.

Right now I've got two big bites on my lower right leg that won't scab over, and I only hope they're from ticks. I'm afraid they might mark the return of leishmanias, the flesh-eating parasite I got covering a story in Bolivia for the *GEOGRAPHIC* a few years ago.

Time will tell.

**FIELD NOTES** Find  of Joel's stories and photos at [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508).



## WORLDWIDE



LUC-HENRI FAGE

**HURRICANE WARNING**

The day before Hurricane Jeanne hammered parts of Florida, writer **Chris Carroll** was mystified by what he saw at the grocery store. "The run on D-cell batteries and weather radios didn't surprise me," he says, "but huge quantities of beer seemed to be the number one item. I saw people filling up carts with everything from cheap domestic brands to obscure imports." The explanation came from a store clerk: Florida counties in the crosshairs of the storm were preparing to issue a ban on alcohol and firearm sales that would last until nearly a week after the storm. "I can understand clamping down on guns during a disaster. But beer? It's like adding insult to injury,"

says Chris. Joining the fray, he bought a few cans. "Somehow the idea of scarcity motivated me. I wound up not even drinking it."

**HANDS ACROSS TIME**

This particular cave in Borneo wasn't on their itinerary, but photographer **Carsten Peter** (above) and speleologist **Luc-Henri Fage** had some time to kill before exploring other caves on the island. And they were intrigued by the claim of a local known as the "man of a thousand caves" that this spot might contain prehistoric handprints. They paid a visit and discovered about 30 hand stencils not far above the floor. Carsten scrambled 15 feet up the cave wall to take a picture of Luc-Henri, who was examining the paintings on the opposite side. But while Carsten, his feet

wedged firmly in crevices, was readying his camera, Luc-Henri turned around and snapped this shot. "It was like a Wild West film," he says. "I shot first."

**TECUMSEH, MISSOURI**

On his first day at the East Wind commune, writer **Alan Malson** met one of the group's most senior members, a man who had moved there in the 1970s. "He was like a chain-smoking Yoda," says Alan. "He turns to me and says, 'Before you ask your questions, I want to ask you mine.'" Alan wasn't prepared for what he got: a grilling on arcane personnel changes at National Geographic going back three decades. He remained mystified by the man's line of inquiry until later that evening. "The commune's outhouses were stocked with hundreds of vintage GEOGRAPHICS," says Alan. "I guess even our mastheads tell a story."

**CHINA'S FOSSIL MARVELS**

Out exploring a dry riverbed in China's fossil-rich Liaoning Province, writer **Cliff Tarp** stumbled on a dinner plate-size piece of shale. "It bore an imprint of what appeared to be a dinosaur forearm and elbow," says Cliff. Thrilled that he might have found a rare and valuable fossil, he rushed back to the nearby dig site and showed it to the chief scientist. Alas, archaeological glory was not in the cards that day. The scientist "patiently informed me that the imprint was of a fern," says Cliff. "A very common fossil."

**TALES FROM THE FIELD**

Find more stories from our contributors, including their best, worst, and quirkiest experiences, in Features at [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508).





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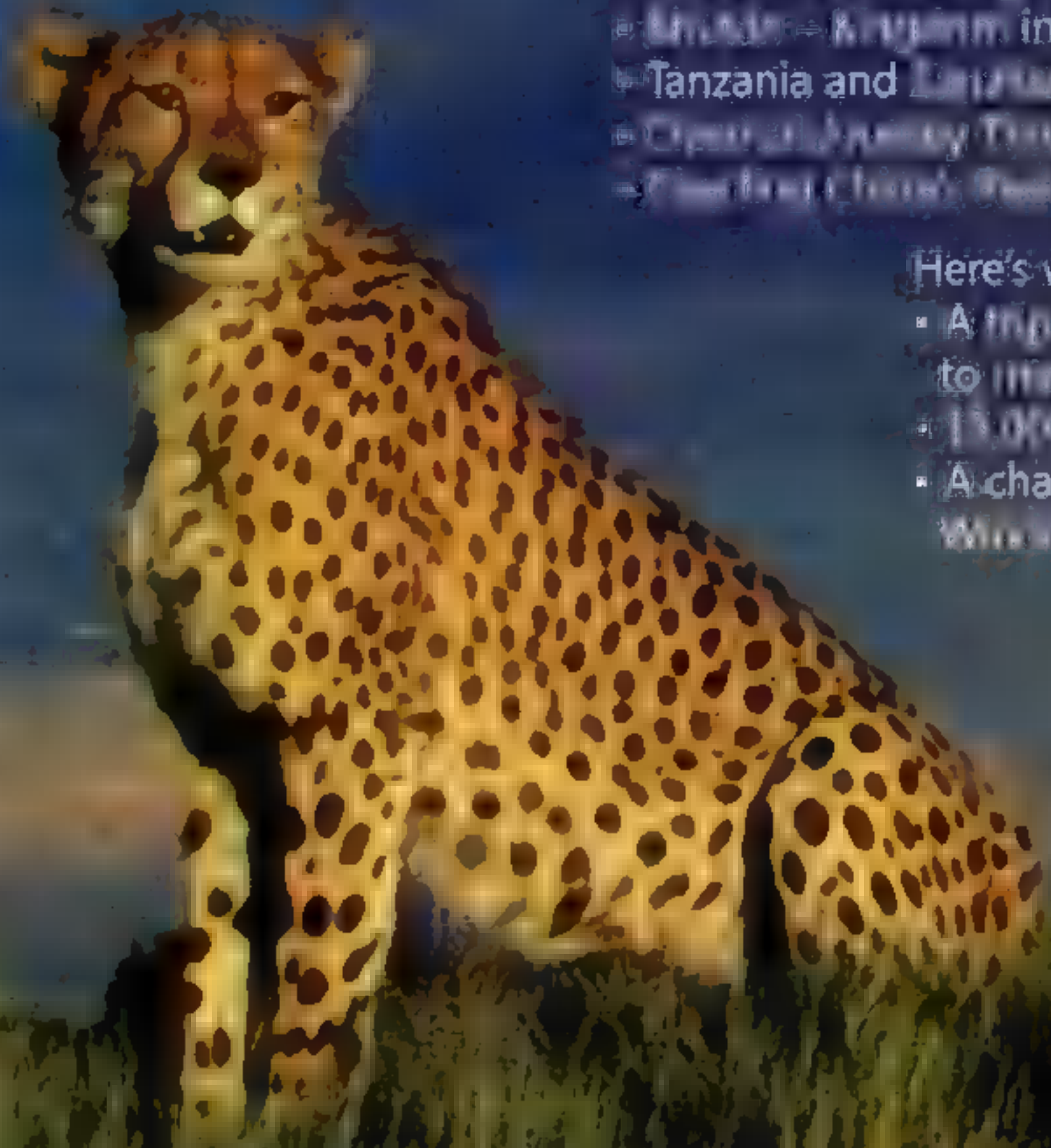
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# Who Knew?

## MENTAL ILLNESS

### Cat Carrier

Your cat could make you crazy

Cats can act a little crazy. One minute they're completely relaxed, purring while you scratch between their ears—then they whip around and carve the mark of Zorro in your hand. They get that spooky look and do high-speed laps around the house. If you have a cat, you've seen all sorts of nutty stuff. But here's something you may not know: Some scientists suspect cats can cause mental illness in people.

A protozoan named *Toxoplasma gondii*, commonly found in cat feces, contaminated water, and undercooked meat, has been implicated in some cases of schizophrenia. Alan S. Brown, a Columbia University professor of psychiatry and epidemiology, has found a 2.6 times greater prevalence of schizophrenia in people exposed to "toxoplasma" in utero. Brown has also reported a threefold increase in the risk of developing schizophrenia in children of mothers who had flu during pregnancy.

This is but one example of a broader suspicion that has recently gotten a lot of attention: Mental illnesses of many types are rooted not in the classic psychological causes but in infections. It's conceivable (though hardly yet proved) that you could catch a brain disorder in much the same way you catch a cold.

E. Fuller Torrey, a psychiatrist with the Stanley Medical Research Institute in Bethesda,

Maryland, has spent more than 30 years searching for what he half jokingly calls the "schizovirus." Yet anyone asking American psychiatrists 40 years ago if an infectious agent could cause schizophrenia "would've been called nuts," Torrey says.

Then in the early 1980s two Australian doctors figured out that peptic ulcers were caused not by stress but most often by bacterial infection. That was a stunning development. Everyone knew that stress caused ulcers! People would say: "This job is giving me an ulcer." No, the microbe did it.

It's long been known that syphilis can trigger psychosis. So can Lyme disease. Both diseases are caused by bacteria called spirochetes that can take up residence in brain tissue, and both are treated with antibiotics. The National Institute of Mental Health has found that some children with obsessive-compulsive disorder and nervous tics have elevated levels of antibodies to the streptococcus bacterium. There's research showing an association between a herpes virus and bipolar disorder. Some researchers think Alzheimer's disease may also have an infectious origin.

That said, studies in this area remain preliminary. Much of the research is built around statistical correlations rather than any clear step-by-step pathway from

infection to disease. Torrey says he and his colleagues don't know why early exposure to toxo would lead to a disease, schizophrenia, that doesn't show up until late adolescence at the earliest. All told, it's still a rather speculative line of argument. But we'll still keep an eye on those crazy cats.

—Joel Achenbach

WASHINGTON POST STAFF WRITER

### Give Me Fever

Neurosyphilis, a form of syphilis that causes mental illness and paralysis, once meant sure death. Mercury, the common treatment for syphilis for centuries, could not cure it. By the 19th century, however, psychiatrists noticed that in rare cases of remission, neurosyphilis patients had often contracted a disease such as typhoid that caused high fever. Some doctors started injecting a curable form of malaria, which triggered fevers exceeding 104°F, into neurosyphilis victims. A dangerous option—but with death the only other one, fever therapy remained widespread until the 1940s, when penicillin became the drug of choice for syphilis.

—Heidi Schultz

**WEBSITE EXCLUSIVE** For more on the role of infections in mental illness, and for links to Joel Achenbach's work, go to Departments at [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508).



# FUTURE

# PPO

WHERE WILL THE  
WORLD GET ITS  
NEXT ENERGY FIX?



Called the Saudi Arabia of wind, the Great Plains hold huge potential for wind power, which has barely been tapped. The sisters at the Sec of Heart Monastery in North Dakota slashed their electric bills by installing two wind turbines. Says princess Marie Hunkler, "We wanted to be a witness to what can happen."



WE'RE





BY MICHAEL PARFIT  
PHOTOGRAPHS BY SARAH LEEN

# FREEDOM!

I stand in a cluttered room surrounded by the debris of electrical enthusiasm: wire peelings, snippets of copper, yellow connectors, insulated pliers. For me these are the tools of freedom. I have just installed a dozen solar panels on my roof, and they work. A meter shows that 1,285 watts of power are blasting straight from the sun into my system, charging my batteries, cooling my refrigerator, humming through my computer, liberating my life.

The euphoria of energy freedom is addictive. Don't get me wrong; I love fossil fuels. I live on an island that happens to have no utilities, but otherwise my wife and I have a normal American life. We

don't want propane refrigerators, kerosene lamps, or composting toilets. We want a lot of electrical outlets and a cappuccino maker. But when I turn on those panels, wow!

Maybe that's because for me, as for most Americans, one energy crisis or another has shadowed most of the past three decades. From the OPEC crunch of the 1970s to the skyrocketing cost of oil and gasoline today, the world's concern over energy has haunted presidential speeches, congressional campaigns, disaster books, and my own sense of well-being with the same kind of gnawing unease that characterized the Cold War.

As NATIONAL GEOGRAPHIC reported in June 2004, oil, no longer cheap, may soon decline. Instability where most oil is found, from the Persian Gulf to Nigeria to Venezuela, makes this lifeline fragile. Natural gas can be hard to transport and is prone to shortages. We won't run out of coal anytime soon, or the largely untapped deposits







of tar sands and oil shale. But it's clear that the carbon dioxide spewed by coal and other fossil fuels is warming the planet, as this magazine reported last September.

Cutting loose from that worry is enticing. With my new panels, nothing stands between me and limitless energy—no foreign nation, no power company, no carbon-emission guilt. I'm free!

Well, almost. Here comes a cloud.

Shade steals across my panels and over my heart. The meter shows only 120 watts. I'm going to have to start the generator and burn some

**OIL ADDICTION**  
Every 24 hours California's Carson Refinery produces seven million gallons of gasoline—only 14 percent of the state's daily diet. Oil is king, but with supplies tight and production expected to peak in the next few decades, the future depends on finding an heir.

more gasoline. This isn't going to be easy after all.

The trouble with energy freedom is that it's addictive; when you get a little, you want a lot. In microcosm I'm like people in government, industry, and private life all over the world, who have tasted a bit of this curious and compelling

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kind of liberty and are determined to find more.

Some experts think this pursuit is even more important than the war on terrorism. "Terrorism doesn't threaten the viability of the heart of our high-technology lifestyle," says Martin Hoffert, a professor of physics at New York University. "But energy really does."

Energy conservation can stave off the day of

reckoning, but in the end you can't conserve what you don't have. So Hoffert and others have no doubt: It's time to step up the search for the next great fuel for the hungry engine of humankind.

Is there such a fuel? The short answer is no. Experts say it like a mantra: "There is no silver bullet." Though a few true believers claim that only vast conspiracies or lack of funds stand





between us and endless energy from the vacuum of space or the core of the Earth, the truth is that there's no single great new fuel waiting in the heart of an equation or at the end of a drill bit.

Enthusiasm about hydrogen-fueled cars may give the wrong impression. Hydrogen is not a source of energy. It's found along with oxygen in plain old water, but it isn't there for the taking. Hydrogen has to be freed before it is useful, and that costs more energy than the hydrogen gives back. These days, this energy comes mostly from fossil fuels. No silver bullet there.

The long answer about our next fuel is not so grim, however. In fact, plenty of contenders for the energy crown now held by fossil fuels are

## A SLOWER BURN

**At a Louisiana coal depot, electrician Randal Brown holds a bright idea: a compact fluorescent lamp (CFL). Much of the world's electricity is produced in coal-fired generators that belch carbon dioxide, mercury, and sulfur into the atmosphere. A CFL lasts longer and consumes far less power than a conventional bulb, cutting energy costs, reducing greenhouse emissions, and saving nearly a quarter ton of coal over its lifetime.**

already at hand: wind, solar, even nuclear, to name a few. But the successor will have to be a congress, not a king. Virtually every energy expert I met did something unexpected: He pushed not just his own specialty but everyone else's too.

"We're going to need everything we can get from biomass, everything we can get from solar, everything we can get from wind," says Michael Pacheco, director of the National Bioenergy Center, part of the National Renewable Energy Laboratories (NREL) in Golden, Colorado. "And still the question is, can we get enough?"

The big problem is big numbers. The world uses some 320 billion kilowatt-hours of energy a day. It's equal to about 22 bulbs burning nonstop for every person on the planet. No wonder the sparkle is seen from space. Hoffert's team estimates that within the next century humanity could use three times that much. Fossil fuels have met the growing demand because they pack millions of years of the sun's energy into a compact form, but we will not find their like again.

Fired up by my taste of energy freedom, I went looking for technologies that can address those numbers. "If you have a big problem, you must give a big answer," says a genial energy guru named Hermann Scheer, a member of the German parliament. "Otherwise people don't believe."

The answers are out there. But they all require one more thing of us humans who huddle around the fossil fuel fire: We're going to have to make a big leap—toward a different kind of world.

## SOLAR: FREE ENERGY, AT A PRICE

**O**n a cloudy day near the city of Leipzig in the former East Germany, I walked across a field of fresh grass, past a pond where wild swans fed. The field (Continued on page 17)





Once small and quaint, these windmills, Denmark is now known for giants like those in the Horns Revs wind farm, where a technician comes in for a checkup. In Denmark wind generates about 20 percent of all electricity. Globally, wind supplies less than one percent of electric power, but it's the fastest growing source.





### WIND RESISTANCE

While popular for the green energy they provide, turbines can also generate powerful protests. They take up large swaths of land, and some critics say they're noisy, unsightly, and a threat to birds and bats. Upset about a new installation, residents of Drenkow, Germany, display anti-turbine posters (below); nearby, the

foundation for a new turbine bears the spray-painted word "no," in German (above). Such sentiments sometimes shove wind farms offshore, but even sea-based wind power isn't always welcome. A proposed wind farm off Cape Cod, Massachusetts, met fierce opposition from residents who feared it would spoil the vistas.





# EUROPE'S AMBITIONS

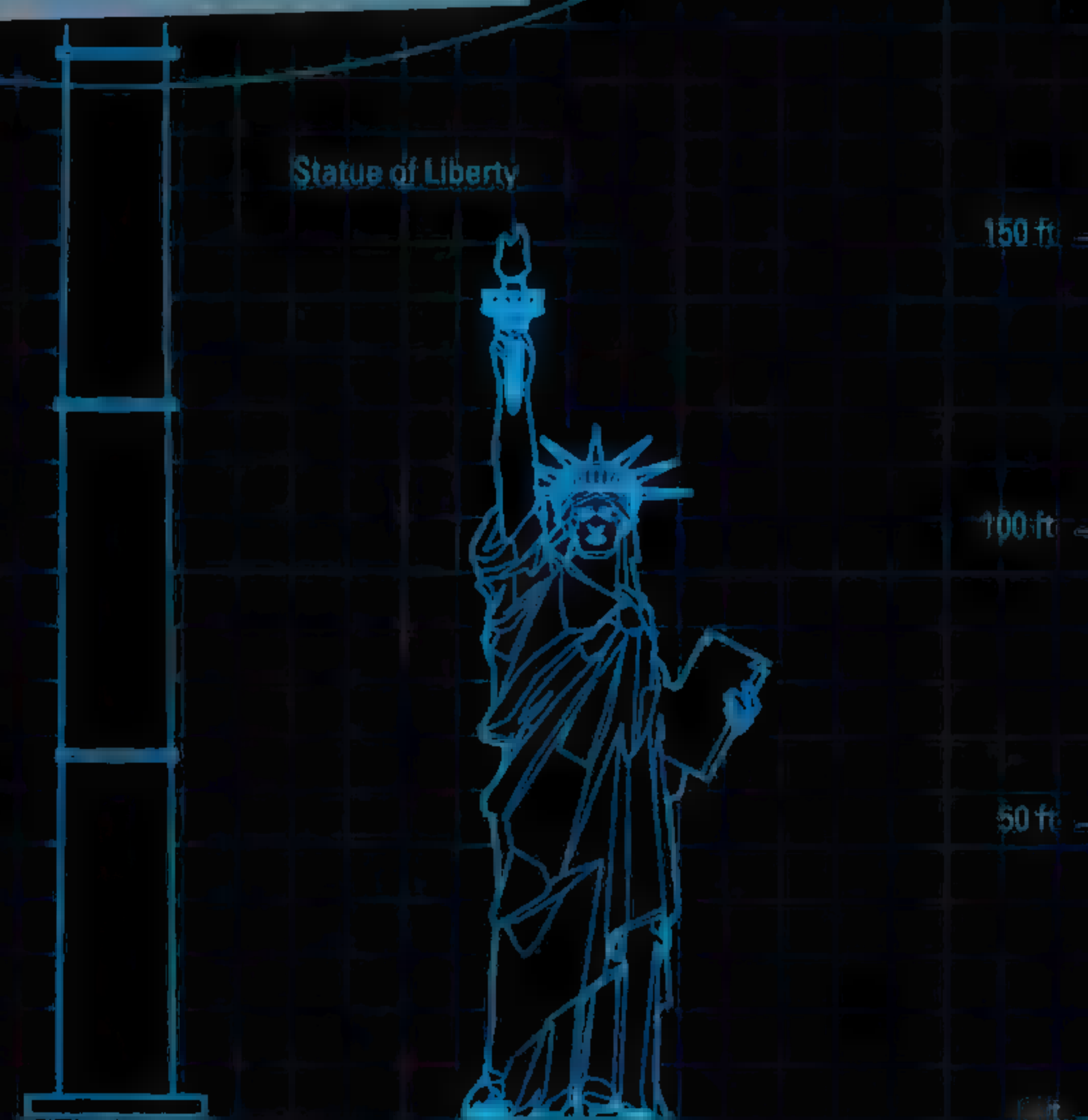
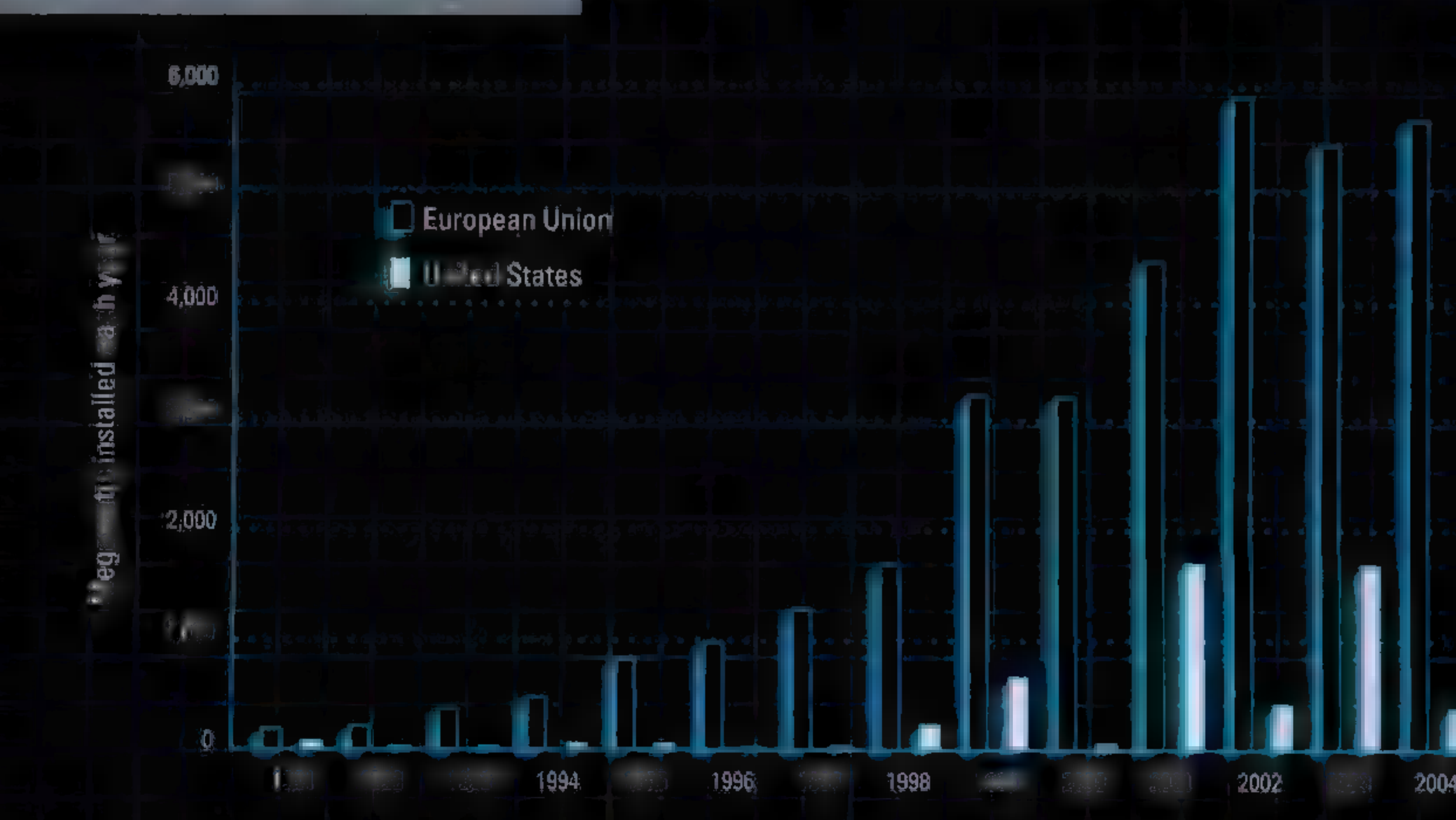
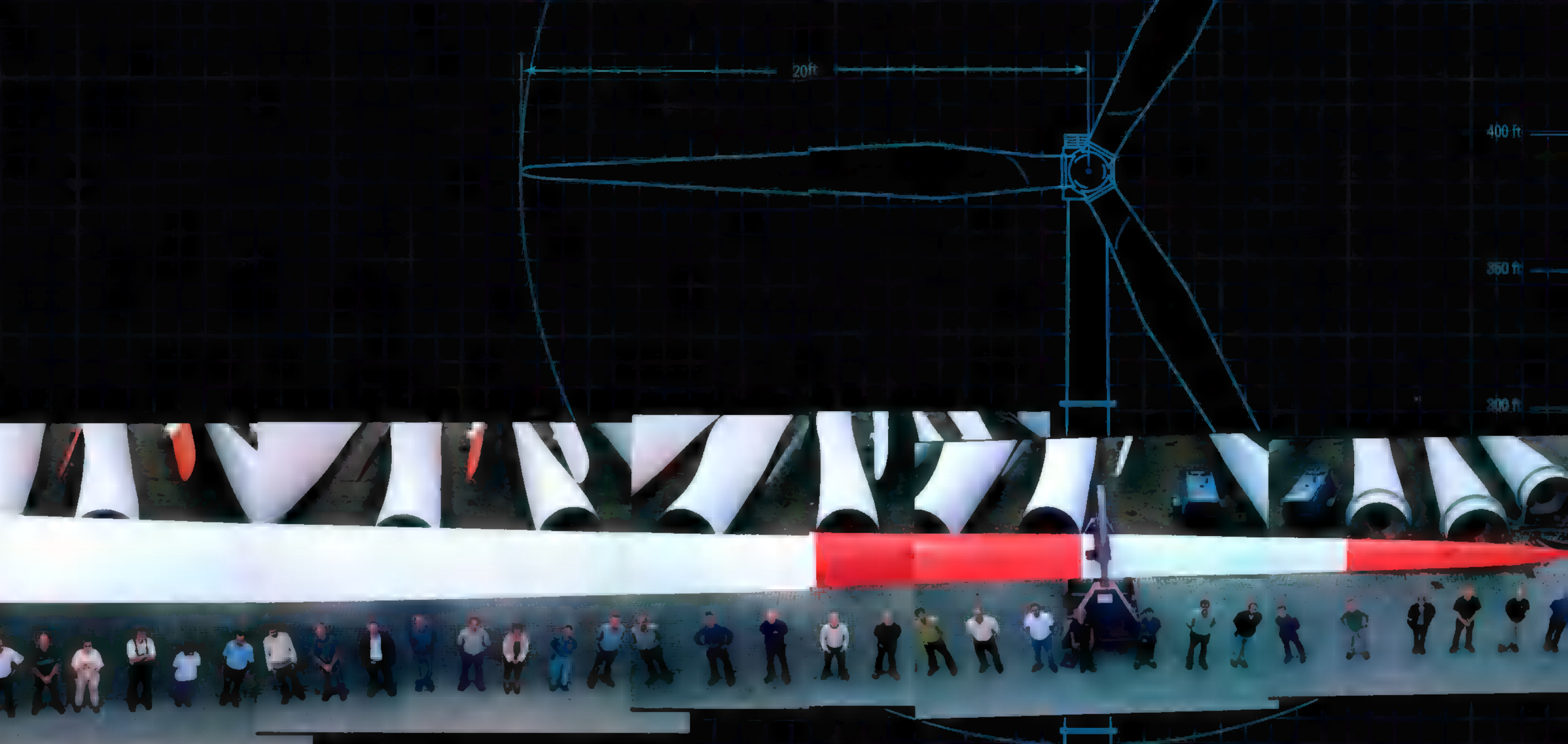
## BUILDING THE WORLD'S BIGGEST WIND TURBINE



Eighteen tons of fiberglass and carbon fiber went into a 200-foot blade built in Denmark for a turbine 650 feet tall. The five-megawatt titan, a prototype for turbines to be erected off the coast of Germany, will average enough power for 5,000 homes. The turbine embodies the European Union's enthusiasm—and generous

support—for alternative energy. The United States lags far behind in new wind-power capacity each year (chart, right). Energy policy expert Dan Kammen compares the U.S. to a hunter-gatherer, constantly scouting for new fossil fuel sources when "we should probably be more like farmers. Energy farming is the future."

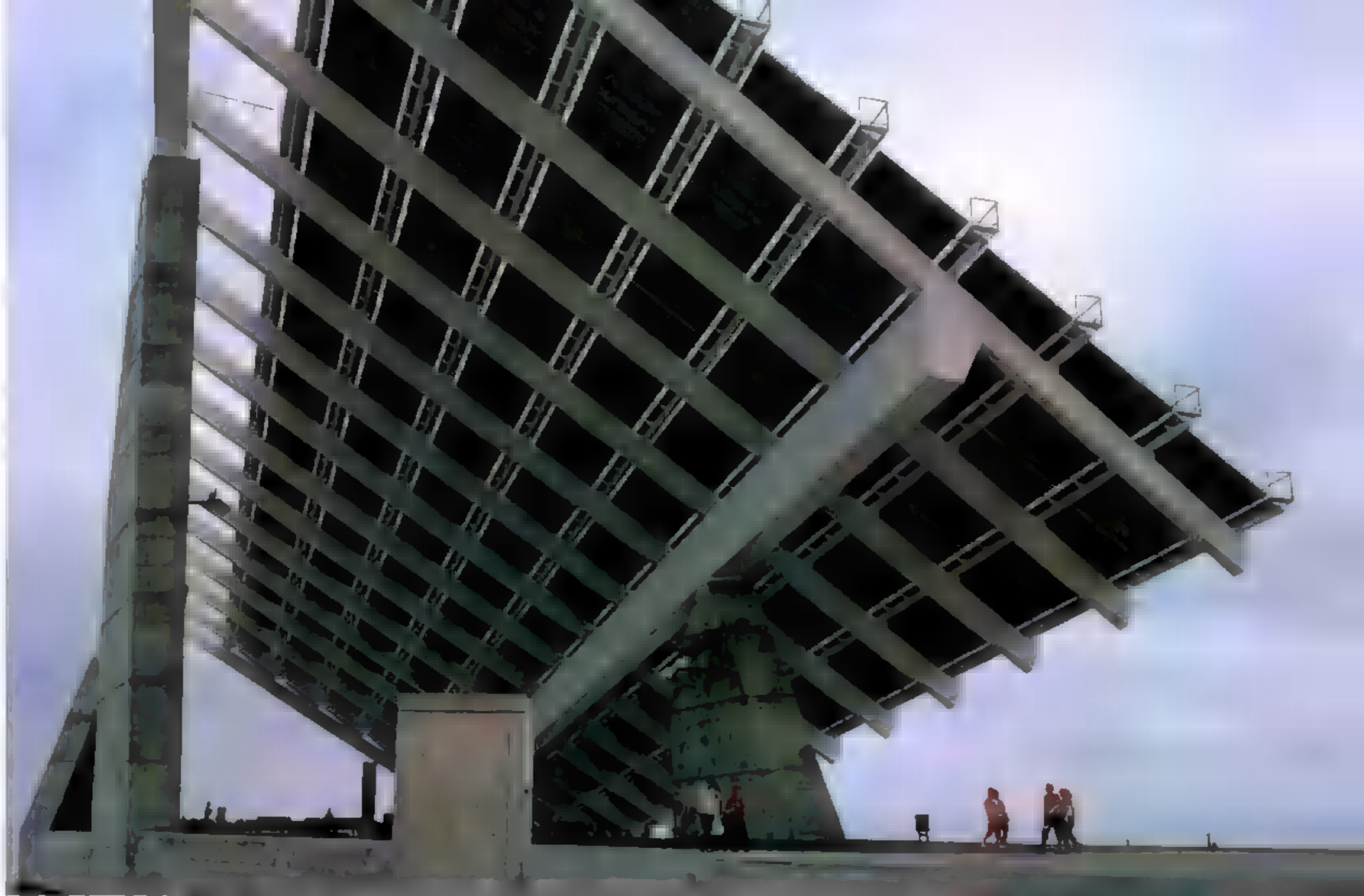












(Continued from page 7) was also sown with 33,500 photovoltaic panels, planted in rows like silver flowers all turned sunward, undulating gently across the contours of the land. It's one of the largest solar arrays ever. When the sun emerges, the field produces up to five megawatts of power, and it averages enough for 1,800 homes.

Nearby are gaping pits where coal was mined for generations to feed power plants and factories. The skies used to be brown with smoke and acrid with sulfur. Now the mines are being turned into lakes, and power that once came from coal is made in a furnace 93 million miles away.

Solar electric systems catch energy directly from the sun—no fire, no emissions. Some labs and companies are trying out the grown-up version of a child's magnifying glass: giant mirrored bowls or troughs to concentrate the sun's rays, producing heat that can drive a generator. But for now, sun power mostly means solar cells.

The idea is simple: Sunlight falling on a layer of semiconductor jostles electrons, creating a current. Yet the cost of the cells, once astronomical, is still high. My modest system cost over \$15,000, about \$10 a watt of capacity, including batteries to store power for when the sun doesn't shine.

Like most things electronic, solar power has been getting cheaper. "Thirty years ago it was cost-effective on satellites," says Daniel Shugar, president of PowerLight Corporation, a fast-growing

## THE ART OF SOLAR

Panels covered with photovoltaic cells capture the sun at a solar park near Leipzig, Germany (left). With 33,500 panels, it is one of the planet's largest arrays. In Barcelona, Spain, a futuristic solar installation doubles as public art (above). The sun now reigns in Spain: A recent law requires new buildings to include solar energy.

California company that has built solar installations for clients including Toyota and Target. "Today it can be cost-effective for powering houses and businesses," at least where utility power is expensive or unavailable. Tomorrow, he says, it will make sense for almost everyone.

Martin Roscheisen, CEO of a company called Nanosolar, sees that future in a set of red-topped vials, filled with tiny particles of semiconductor. "I put some of that on my finger, and it disappeared right into my skin," he says. He won't say exactly what the particles are, but the "nano" in the company name is a hint: They are less than a hundred nanometers across—about the size of a virus, and so small they slip right through skin.

Roscheisen believes those particles promise a low-cost way to create solar cells. Instead of making the cells from slabs of silicon, his company



# PANELS COVERING LESS THAN A QUARTER OF THE ROOF AND PAVEMENT SPACE IN CITIES AND SUBURBS COULD SUPPLY THE U.S. WITH ALL ITS ELECTRICITY.

will paint the particles onto a foil-like material, where they will self-assemble to create a semiconductor surface. The result: a flexible solar-cell material 50 times thinner than today's solar panels. Roscheisen hopes to sell it in sheets, for about 50 cents a watt.

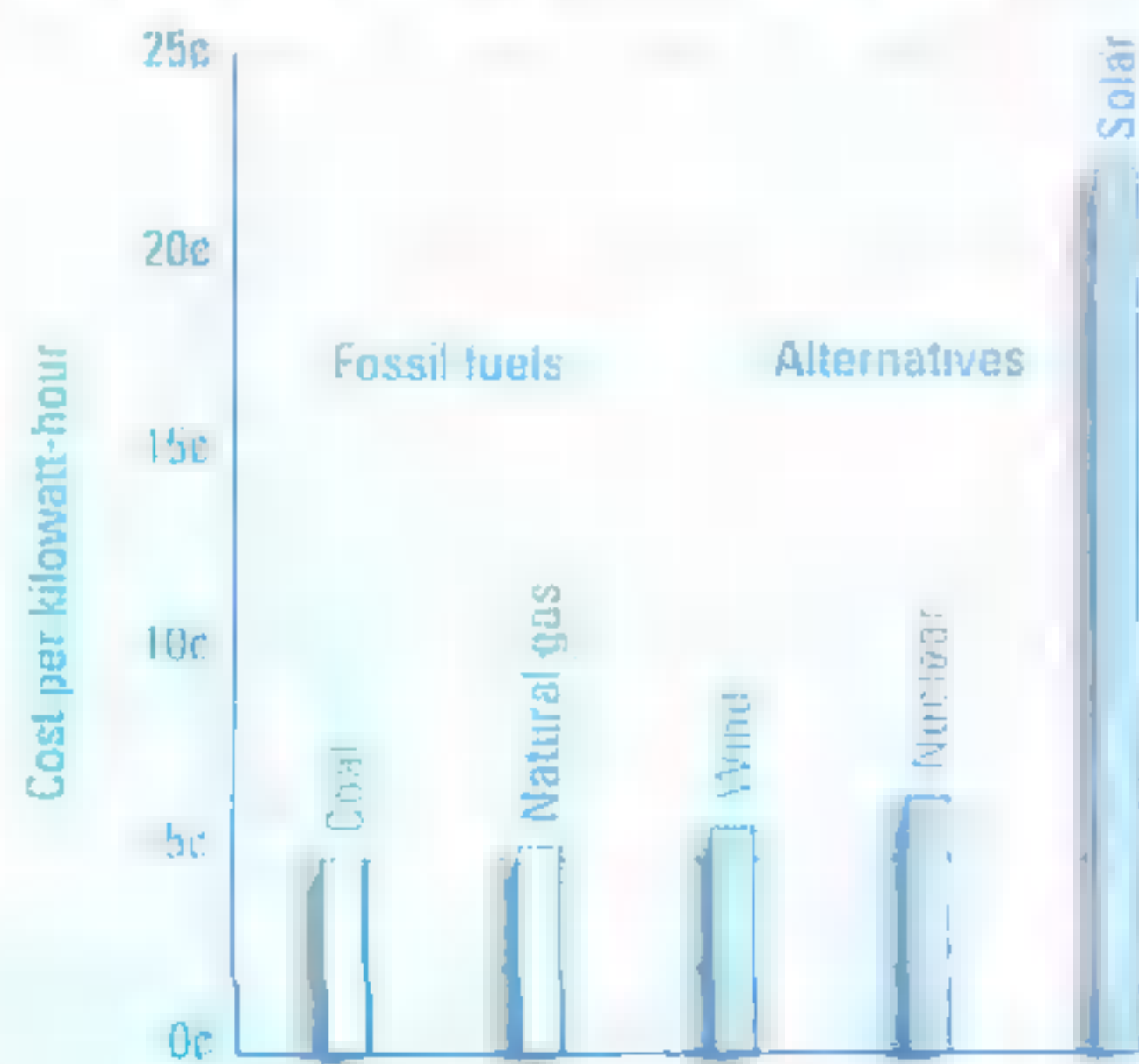
"Fifty cents a watt is kind of the holy grail," says David Pearce, president and CEO of Mia-solé, one of many other companies working on "thin-film" solar cells. At that price solar could compete with utilities and might take off. If prices continued to drop, solar cells might change the whole idea of energy by making it cheap and easy for individuals to gather for themselves. That's what techies call a "disruptive technology."

"Automobiles were disruptive to the horse and buggy business," Dan Shugar says. "PCs were disruptive to the typewriter industry. We believe solar electric systems will be disruptive to the energy industry."

Yet price isn't the only hurdle solar faces. There are the small matters of clouds and darkness, which call for better ways of storing energy than the bulky lead-acid batteries in my system.

## THE COST OF A KILOWATT-HOUR

**Solar power will remain expensive for some time, as shown in a comparison of energy prices calculated for new plants coming online in 2013. But the cost of solar should fall as technology improves.**



But even if those hurdles are overcome, can solar really make the big energy we need?

With solar now providing less than one percent of the world's energy, that would take "a massive (but not insurmountable) scale-up," NYU's Hoffert and his colleagues said in an article in *Science*. At present levels of efficiency, it would take about 10,000 square miles of solar panels—an area bigger than Vermont—to satisfy all of the United States' electricity needs. But the land requirement sounds more daunting than it is: Open country wouldn't have to be covered. All those panels could fit on less than a quarter of the roof and pavement space in cities and suburbs.

## WIND: FEAST OR FAMINE

**W**ind, ultimately driven by sun-warmed air, is just another way of collecting solar energy, but it works on cloudy days. One afternoon I stood in a field near Denmark's west coast under a sky so dark and heavy it would have put my own solar panels into a coma. But right above me clean power was being cranked out by the megawatt. A blade longer than an airplane wing turned slowly in a strong south breeze. It was a wind turbine.

The turbine's lazy sweep was misleading. Each time one of the three 130-foot blades swung past, it hissed as it sliced the air. Tip speed can be well over 100 miles an hour. This single tower was capable of producing two megawatts, almost half the entire output of the Leipzig solar farm.

In Denmark, turning blades are always on the horizon, in small or large groups, like spokes of wheels rolling toward a strange new world. Denmark's total installed wind power is now more than 3,000 megawatts—about 20 percent of the nation's electrical needs. All over Europe generous incentives designed to reduce carbon emissions and wean economies from oil and coal have led to a wind boom. The continent leads the world in wind power, with almost 35,000 megawatts, equivalent to 35 large coal-fired power plants. North America, even though it



## POWER BREAKDOWN

Without global changes, energy consumption from fossil fuels will leap, generating more climate-altering carbon dioxide (blue circles). If today's trends continue, the use of alternative energy sources won't rise much (bottom of each bar). "We're running out of atmosphere faster than we're running out of fossil fuels," says energy scientist Dan Kammen. "The more we diversify our sources, the better."

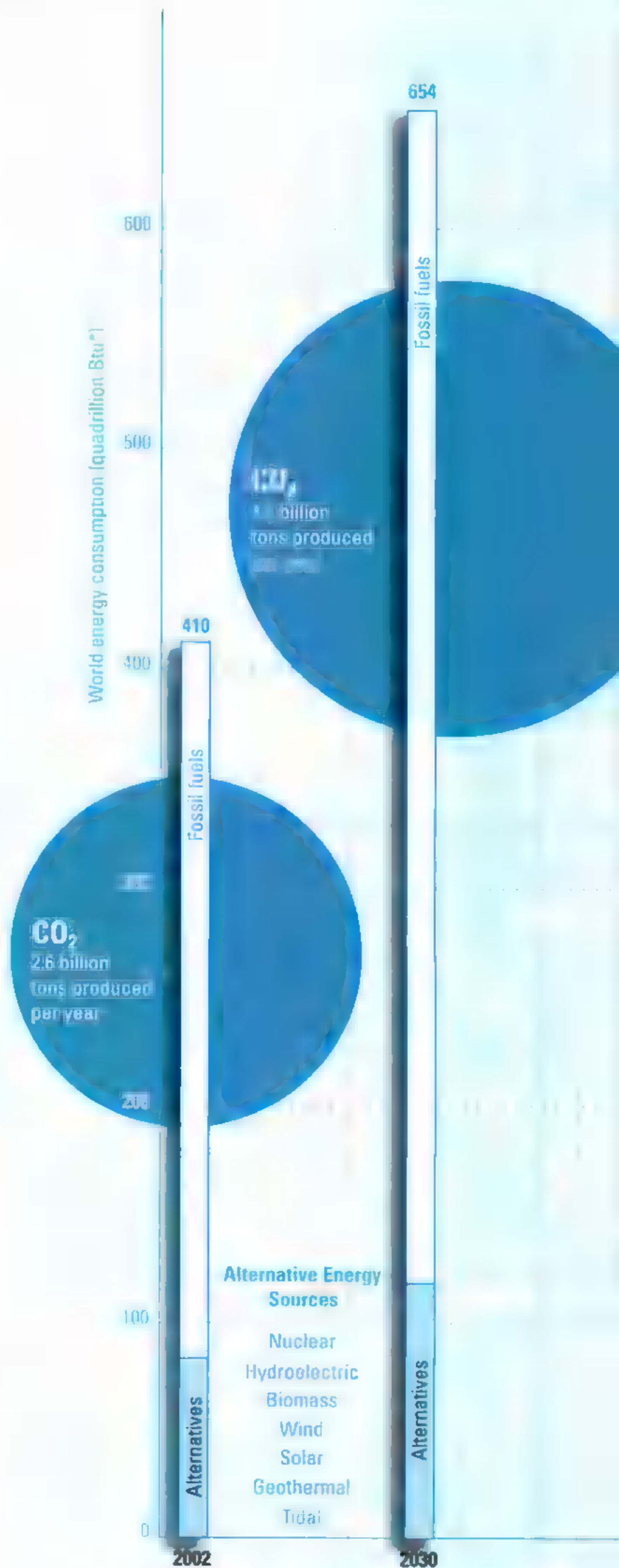
has huge potential for wind energy, remains a distant second, with just over 7,000 megawatts. With the exception of hydroelectric power—which has been driving machines for centuries but has little room to grow in developed countries—wind is currently the biggest success story in renewable energy.

"When I started in 1987, I spent a lot of time sitting in farmers' houses until midnight talking to the neighbors, just selling one turbine," says Hans Buus. He's director of project development for a Danish energy company called Elsam. "I would not have been able to imagine the level it is today."

He means not only the number of turbines but also their sheer size. In Germany I saw a fiberglass-and-steel prototype that stands 600 feet tall, has blades 200 feet long, and can generate five megawatts. It's not just a monument to engineering but also an effort to overcome some new obstacles to wind power development.

One is aesthetic. England's Lake District is a spectacular landscape of bracken-clad hills and secluded valleys, mostly protected as a national park. But on a ridge just outside the park, though not outside the magnificence, 27 towers are planned, each as big as the two-megawatt machine in Denmark. Many locals are protesting. "This is a high-quality landscape," says one. "They shouldn't be putting those things in here."

Danes seem to like turbines more than the British, perhaps because many Danish turbines belong to cooperatives of local residents. It's harder to say "not in my backyard" if the thing in your backyard helps pay for your house. But environmental opposition is not the only trouble facing wind development. Across Europe many of the windiest sites are already occupied. So the five-megawatt German machine is



\*One Btu (British thermal unit) approximately equals energy released when a wooden match is burned



# HYDROGEN FUTURES

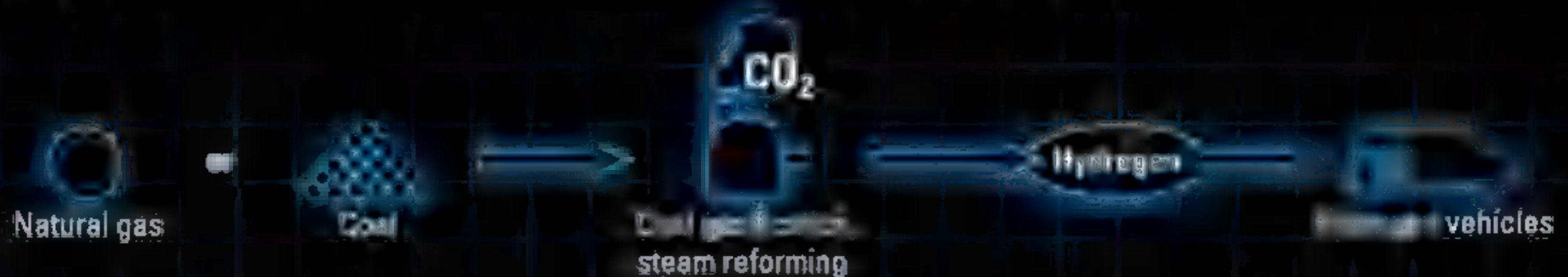
CLEAN FUEL? DEPENDS ON HOW YOU MAKE IT.



## CONVENTIONAL TECHNOLOGY

Hydrogen could power the nonpolluting cars of tomorrow, but the gas itself must be generated using other energy sources. As shown in this artist's interpretation, hydrogen would be only as ecofriendly as the original energy

source. Current technology produces hydrogen from fossil fuel and releases carbon dioxide (CO<sub>2</sub>) and other pollutants. Scaling up the process would add to global warming and its potential effects, such as intensified storms.



Natural gas or gas from coal yields hydrogen when heated and chemically reacted with steam; the process gives off carbon dioxide.





ART BY STEPHAN [unreadable] AND CHARLES [unreadable], NGM ART (BOTTOM)

## ZERO EMISSIONS TECHNOLOGY

In a greener future, hydrogen would be produced with carbon dioxide-free energy, requiring a massive expansion of wind, solar, or nuclear power. The U.S. government is also studying the possibility of exploiting

the country's vast coal reserves to make hydrogen but storing the carbon dioxide safely underground—a strategy that remains unproven. Other hurdles include developing practical hydrogen-powered cars.



Clean hydrogen could be made from water with electricity from emissions-free sources; coal could also be a clean source if the CO<sub>2</sub> was buried.



designed to help take wind power away from the scenery and out to abundant new sites at sea.

Many coastlines have broad areas of shallow continental shelf where the wind blows more steadily than on land and where, as one wind expert puts it, "the seagulls don't vote." (Real voters, however, sometimes still object to the sight of towers on the horizon.) It costs more to build and maintain turbines offshore than on land, but an underwater foundation for a five-megawatt tower is cheaper per megawatt than a smaller foundation. Hence the German giant.

There are other challenges. Like sailboats, wind turbines can be becalmed for days. To keep the grid humming, other sources, such as coal-fired power plants, have to stand ready to take up the slack. But when a strong wind dumps power into the grid, the other generators have to be turned down, and plants that burn fuel are not quickly adjustable. A wind-power bonanza can become a glut. Denmark, for example, is sometimes forced to unload power at uneconomic rates to neighbors like Norway and Germany.

What's needed for wind as well as solar is a

and remote sites like lighthouses and weather stations. At 400 watts apiece they can't power more than a few lights.

But David Calley, Southwest's president, whose father built his first wind turbine out of washing machine parts, is testing a new product he calls an energy appliance. It will stand on a tower as tall as a telephone pole, produce up to two kilowatts in a moderate wind, and come with all the electronics needed to plug it into the house.

Many U.S. utilities are required to pay for power that individuals put back into the grid, so anyone in a relatively breezy place could pop up the energy appliance in the yard, use the power when it's needed, and feed it back into the grid when it's not. Except for the heavy loads of heating and air-conditioning, this setup could reduce a home's annual power bill to near zero. If, as Calley hopes, he can ultimately sell the energy appliance for under \$3,000, it would pay for itself with energy savings within a few years.

Somewhere in this mix of the grand and the personal, there may be big numbers in wind too.

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## WIND IS CURRENTLY THE BIGGEST SUCCESS STORY IN RENEWABLE ENERGY. EUROPE'S TURBINES CAN GENERATE THE POWER OF 35 COAL-FIRED PLANTS.

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way to store a large energy surplus. Technology already exists to turn it into fuels such as hydrogen or ethanol or harness it to compress air or spin flywheels, banking energy that can later churn out electricity. But most systems are still decades from becoming economically feasible.

On the plus side, both wind and solar can provide what's called distributed energy: They can make power on a small scale near the user. You can't have a private coal plant, but you can have your own windmill, with batteries for calm days. The more houses or communities make their own wind power, the smaller and cheaper central power plants and transmission lines can be.

In Europe's big push toward wind power, the turbines keep growing. But in Flagstaff, Arizona, Southwest Windpower makes turbines with blades you can pick up in one hand. The company has sold about 60,000 of the little turbines, most of them for off-grid homes, sailboats,

### BIOMASS: FARMING YOUR FUEL

In Germany, driving from the giant wind turbine near Hamburg to Berlin, I regularly got an odd whiff: the sort-of-appetizing scent of fast food. It was a puzzle until a tanker truck passed, emblazoned with the word "biodiesel." The scent was of burning vegetable oil. Germany uses about 450 million gallons of biodiesel a year, about 3 percent of its total diesel consumption.

Biomass energy has ancient roots. The logs in your fire are biomass. But today biomass means ethanol, biogas, and biodiesel—fuels as easy to burn as oil or gas, but made from plants. These technologies are proven. Ethanol produced from corn goes into gasoline blends in the U.S.; ethanol from sugarcane provides 50 percent of automobile fuel in Brazil. In the U.S. and other nations, biodiesel from vegetable oil is burned, pure or mixed with regular diesel, in unmodified engines. "Biofuels are the easiest fuels to slot into





the existing fuel system,” says Michael Pacheco, the National Bioenergy Center director.

What limits biomass is land. Photosynthesis, the process that captures the sun’s energy in plants, is far less efficient per square foot than solar panels, so catching energy in plants gobbles up even more land. Estimates suggest that powering all the world’s vehicles with biofuels would mean doubling the amount of land devoted to farming.

At the National Bioenergy Center, scientists are trying to make fuel-farming more efficient. Today’s biomass fuels are based on plant starches, oils, and sugars, but the center is testing organisms that can digest woody cellulose, abundant in plants, so that it too could yield liquid fuel. More productive fuel crops could help as well.

One is switchgrass, a plant native to North America’s prairies that grows faster and needs less fertilizer than corn, the source of most ethanol fuel made in the U.S. It also thrives on land unfit for other crops and does double duty as a source of animal food, further reducing the pressure on farmland.

“Preliminary results look promising,” says Thomas Foust, the center’s technology manager. “If you increase automobile efficiency to the

## AHEAD OF THE CURVE

**In Hamburg, Germany, clean, quiet hydrogen fuel-cell buses share pavement with grumbling gas-guzzlers.**

**Nine European cities operate the buses as part of the EU’s CUTE (Clean Urban Transport for Europe) program; Hamburg, Amsterdam, and Stockholm produce their hydrogen entirely with renewable energy.**

level of a hybrid and go with the switchgrass crop mix, you could meet two-thirds of the U.S. transportation fuel demand with no additional land.”

But technically possible doesn’t mean politically feasible. From corn to sugarcane, all crops have their own lobbyists. “We’re looking down a lot of alleys,” says Pacheco. “And every alley has its own vested interest group. Frankly, one of the biggest challenges with biomass is that there are so many options.”





## NUCLEAR: STILL A CONTENDER

**N**uclear fission appeared to lead the race as an energy alternative decades ago, as countries began building reactors. Worldwide, about 440 plants now generate 16 percent of the







**"You don't have to drive a freaky  to  biodiesel,"** says Jacques Chiron of Corvallis, Oregon, who powers his Astroturf-covered Volkswagen with used vegetable oil. Biofuels such as biodiesel and ethanol  made from fat, corn, and other organic sources. Chiron gets oil free from  potato-chip shop and says he spends eight dollars a month to fuel his car.







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## POWERING ALL THE WORLD'S VEHICLES WITH BIOFUELS WOULD MEAN DOUBLING THE AMOUNT OF LAND DEVOTED TO FARMING.

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planet's electric power, and some countries have gone heavily nuclear. France, for instance, gets 78 percent of its electricity from fission.

The allure is clear: abundant power, no carbon dioxide emissions, no blots on the landscape except an occasional containment dome and cooling tower. But along with its familiar woes—the accidents at Three Mile Island and Chernobyl, poor economics compared with fossil fuel plants, and the challenge of radioactive waste disposal—nuclear power is far from renewable. The readily available uranium fuel won't last much more than 50 years.

Yet enthusiasm is reviving. China, facing a shortage of electric power, has started to build new reactors at a brisk pace—one or two a year. In the U.S., where some hydrogen-car boosters see nuclear plants as a good source of energy for making hydrogen from water, Vice President Dick Cheney has called for “a fresh look” at

nuclear. And Japan, which lacks its own oil, gas, and coal, continues to encourage a fission program. Yumi Akimoto, a Japanese elder statesman of nuclear chemistry, saw the flash of the bomb at Hiroshima as a boy yet describes nuclear fission as “the pillar of the next century.”

In the town of Rokkasho at the northernmost tip of Honshu Island, Japan is working to get around the limits of the uranium supply. Inside a new 20-billion-dollar complex, workers wear pale blue work suits and an air of patient haste. I looked in on cylindrical centrifuges for enriching uranium and a pool partly filled with rods of spent nuclear fuel, cooling. Spent fuel is rich in plutonium and leftover uranium—valuable nuclear material that the plant is designed to salvage. It will “reprocess” the spent fuel into a mixture of enriched uranium and plutonium called MOX, for *mixed oxide fuel*. MOX can be burned in some modern reactors and could





stretch the fuel supply for decades or more.

Reprocessing plants in other countries also turn spent fuel into MOX. But those plants originally made plutonium for nuclear weapons, so the Japanese like to say that theirs, due to start up in 2007, is the first such plant built entirely for peaceful use. To assure the world that it will stay that way, the Rokkasho complex includes a building for inspectors from the International Atomic Energy Agency, the United Nations' nuclear watchdog, who will make certain that none of the plutonium is diverted for weapons.

That doesn't satisfy nuclear energy opponents. Opposition has mounted in Japan after fatal accidents at the country's nuclear plants, including one that killed two workers and exposed others to radiation. Shortly after my visit to Rokkasho, about a hundred protesters marched outside the plant in a blizzard.

A bigger controversy would greet what some nuclear proponents think is a crucial next step: a move to breeder reactors. Breeders can make more fuel than they consume, in the form of plutonium that can be extracted by reprocessing the spent fuel. But experimental breeder reactors have proved to be temperamental, and a full-scale breeder program could be an arms-control

## WASTE NOT, WANT NOT

Leftover rice hulls are burned at the Wadham Energy plant in Williams, California (left), to generate electricity. Outside Sacramento, hoses suck methane from decomposing trash.

Long overlooked, our endless garbage streams feed a growing market that recycles biomass (plant and animal waste) and biogas into fuel.

nightmare because of all the plutonium it would put in circulation.

Akimoto, for one, believes that society has to get comfortable with fuel reprocessing if it wants to count on nuclear energy. He spoke to me through an interpreter, but to emphasize this point he jumped into English: "If we are going to accept nuclear power, we have to accept the total system. Sometimes we want to get the first crop of fruit but forget how to grow the trees."

## FUSION: THE FIRE SOME TIME

Fusion is the gaudiest of hopes, the fire of the stars in the human hearth. Produced when two atoms fuse into one, fusion energy could satisfy huge chunks of future demand. The fuel



# A GREENER GOTHAM

## IMAGINING NEW YORK WITHOUT FOSSIL FUELS

It takes a lot to make Broadway shine and Yankee Stadium glow—not to mention light the rest of New York City. Suppose the Big Apple were to set a big example by dumping dirty fuels for greener energy? The map at right shows how much space would go to energy production if New Yorkers picked a single clean technology to generate 60 percent of their electricity—the amount now produced by coal and natural gas. Solar and wind need extra space to make up for the fact that they can't always produce at full capacity.

### SOLAR

74 sq mi

145,225,714  
64" x 32" panels  
175 watts each



### WIND

10.6 sq mi

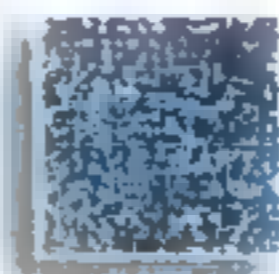
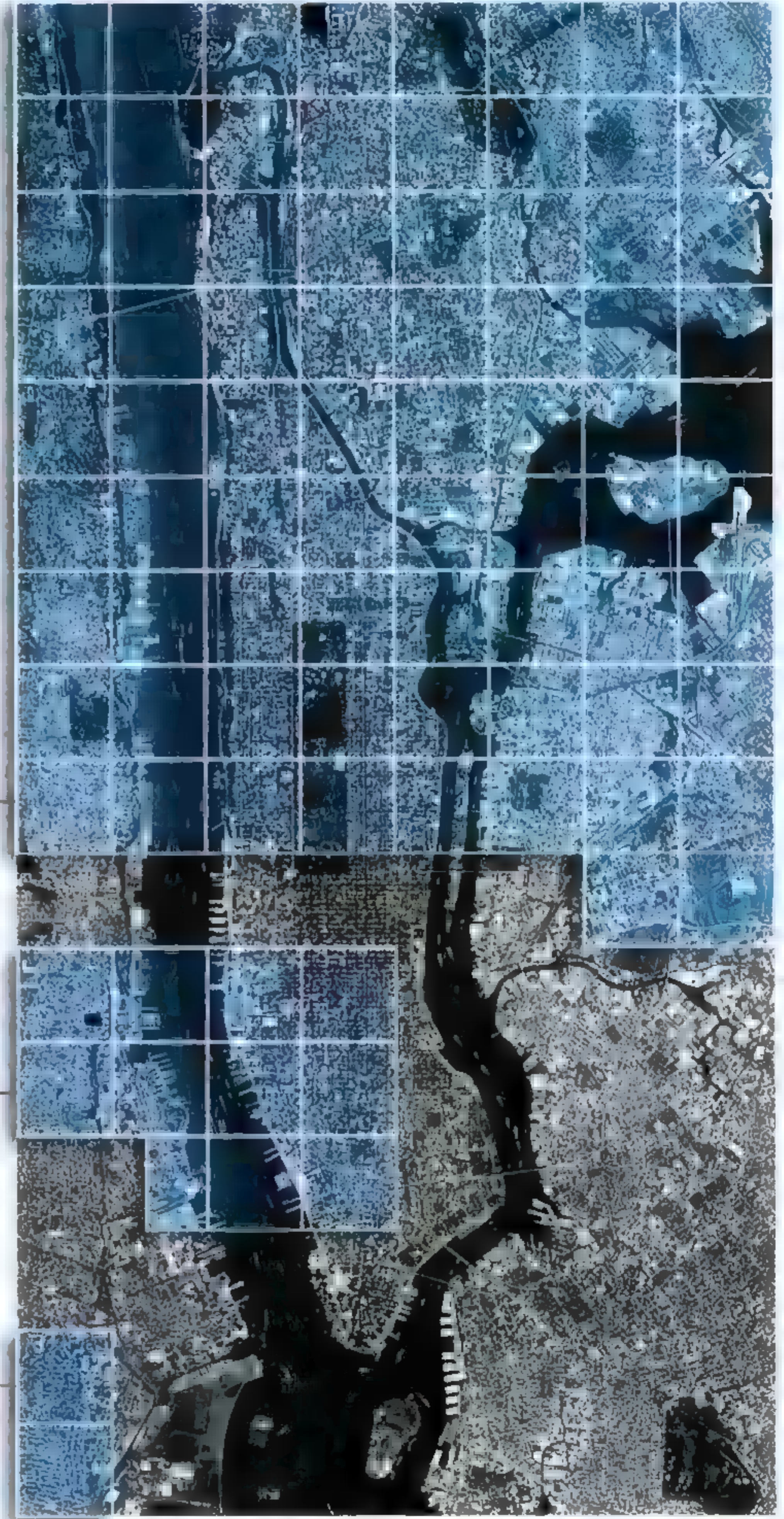
6,800 turbines  
1.5 megawatts each



### NUCLEAR

2 sq mi

4 reactors  
1,000 megawatts each



Grid square on map equals one square mile.



would last millennia. Fusion would produce no long-lived radioactive waste and nothing for terrorists or governments to turn into weapons. It also requires some of the most complex machinery on Earth.

A few scientists have claimed that cold fusion, which promises energy from a simple jar instead of a high-tech crucible, might work. The verdict so far: No such luck. Hot fusion is more likely to succeed, but it will be a decades-long quest costing billions of dollars.

Hot fusion is tough because the fuel—a kind of hydrogen—has to be heated to a hundred million degrees Celsius or so before the atoms start fusing. At those temperatures the hydrogen forms a roiling, unruly vapor of electrically charged particles, called plasma. “Plasma is the most common state of matter in the universe,” says one physicist, “but it’s also the most chaotic and the least easily controlled.” Creating and containing plasma is so challenging that no fusion experiment has yet returned more than 65 percent of the energy it took to start the reaction.

Now scientists in Europe, Japan, and the U.S.

shaped like a doughnut—the standard design for most fusion efforts, including ITER. The physicists sent a huge electrical charge into the gas-filled container, a scaled-down version of JET. It raised the temperature to about ten million degrees Celsius, not enough to start fusion but enough to create plasma.

The experiment lasted a quarter of a second. A video camera shooting 2,250 frames a second captured it. As it played back, a faint glow blossomed in the chamber, wavered, grew into a haze visible only on its cooling edges, and vanished.

It was—well, disappointing. I had expected the plasma to look like a movie shot of an exploding automobile. This was more like a ghost in an English paneled library.

But this phantom was energy incarnate: the universal but elusive magic that all our varied technologies—solar, wind, biomass, fission, fusion, and many others large or small, mainstream or crazy—seek to wrestle into our service.

Taming that ghost is not just a scientific challenge. The ITER project has been held up by a seemingly simple problem. Since 2003 the

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## WITHOUT A BIG PUSH FROM GOVERNMENT, SAYS ONE EXPERT, WE MAY BE CONDEMNED TO RELY ON DIRTY FUELS AS CLEANER ONES LIKE OIL AND GAS RUN OUT.

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are refining the process, learning better ways to control plasma and trying to push up the energy output. They hope that a six-billion-dollar test reactor called ITER will get the fusion bonfire blazing—what physicists call “igniting the plasma.” The next step would be a demonstration plant to actually generate power, followed by commercial plants in 50 years or so.

“I am 100 percent sure we can ignite the plasma,” says Jerome Pamela, the project manager of a fusion machine called the Joint European Torus, or JET, at Britain’s Culham Science Center. “The biggest challenge is the transition between the plasma and the outside world.” He means finding the right materials for the lining of the ITER plasma chamber, where they will have to withstand a bombardment of neutrons and transfer heat to electric generators.

At Culham I saw an experiment in a tokamak, a device that cages plasma in a magnetic field

participating countries—including much of the developed world—have been deadlocked over where to build the machine. The choice has come down to two sites, one in France and one in Japan.

As all energy experts will tell you, this proves a well-established theory. There’s only one force tougher to manage than plasma: politics.

**A**lthough some politicians believe the task of developing the new energy technologies should be left to market forces, many experts disagree. That’s not just because it’s expensive to get new technology started, but also because government can often take risks that private enterprise won’t.

“Most of the modern technology that has been driving the U.S. economy did not come spontaneously from market forces,” NYU’s Martin Hoffert says, ticking off jet planes, satellite communications, integrated circuits, computers.



## STAYING POWER

**After public pressure shut down California's Rancho Seco nuclear power plant in 1989, solar panels took over much of the site. Concerns about radioactive waste, cost, and security once slowed nuclear development. Now ambitious programs may help satiate the appetite for power in China and India, and President George W. Bush has called for new nuclear plants in the U.S. Because they produce vast amounts of electricity, reactors will remain a key piece of the energy puzzle for generations.**

"The Internet was supported for 20 years by the military and for 10 more years by the National Science Foundation before Wall Street found it."

Without a big push from government, he says, we may be condemned to rely on increasingly dirty fossil fuels as cleaner ones like oil and gas run out, with dire consequences for the climate. "If we don't have a proactive energy policy," he says, "we'll just wind up using coal, then shale, then tar sands, and it will be a continually diminishing return, and eventually our civilization will collapse. But it doesn't have to end that way. We have a choice."

It's a matter of self-interest, says Hermann Scheer, the German member of parliament. "I don't appeal to the people to change their conscience," he said in his Berlin office, where a small model of a wind turbine turned lazily in a window. "You can't go around like a priest." Instead, his message is that nurturing new forms of energy is necessary for an environmentally and economically sound future. "There is no alternative."

Already, change is rising from the grass roots. In the U.S., state and local governments are pushing alternative energies by offering subsidies and requiring that utility companies include renewable sources in their plans. And in Europe financial incentives for both wind and solar energy have broad support even though they raise electric bills.

Alternative energy is also catching on in parts of the developing world where it's a necessity, not a choice. Solar power, for example, is making inroads in African communities lacking power lines and generators. "If you want to overcome poverty, what do people need to focus on?" asks Germany's environment minister, Jürgen Trittin.



"They need fresh water and they need energy. For filling the needs of remote villages, renewable energy is highly competitive."

In developed countries there's a sense that alternative energy—once seen as a quaint hippie enthusiasm—is no longer alternative culture. It's edging into the mainstream. The excitement of energy freedom seems contagious.

One afternoon last year, near a village north of Munich, a small group of townspeople and workers inaugurated a solar facility. It would soon surpass the Leipzig field as the largest in the world, with six megawatts of power.

About 15 people gathered on a little man-made hill beside the solar farm and planted four





cherry trees on the summit. The mayor of the tidy nearby town brought out souvenir bottles of schnapps. Almost everyone had a swig, including the mayor.

Then he said he would sing to the project's construction supervisor and a landscape artist, both American women. The two women stood together, grinning, with the field of solar panels soaking up energy behind them. The German mayor straightened his dark suit, and the other men leaned on their shovels.

Fifty years ago, I thought, there were still bombed-out ruins in the cities of Europe. The Soviet Union was planning Sputnik. Texas oil was \$2.82 a barrel. At the most, we have 50 years

to make the world over again. But people change, adapt, and make crazy new stuff work. I thought about Dan Shugar talking about disruptive technologies. "There's a sense of excitement," he had said. "There's a sense of urgency. There's a sense that we cannot fail."

On the hilltop, the mayor took a deep breath. He sang, in a booming tenor, without missing a note or a word, the entire song "O Sole Mio." Everyone cheered. □

**SOUND OFF** What is the future of alternative energy? Would you live near a nuclear power plant? Share your thoughts in our forum, find more photographs, and read field notes from photographer and author at [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508).



# Hands Across Time

## Exploring the Rock Art of Borneo

Stencils of hands with mysterious symbols branch from a "tree of life" on a cave wall in the rain forest of eastern Borneo. Through a series of expeditions, a French-Indonesian team has discovered hundreds of such paintings in over 30 caves. Dated back to more than 10,000 years ago, the oldest of this rock art may suggest initiation or shamanistic rituals and may be related to prehistoric Aboriginal art in Australia—a hint at early human migration.

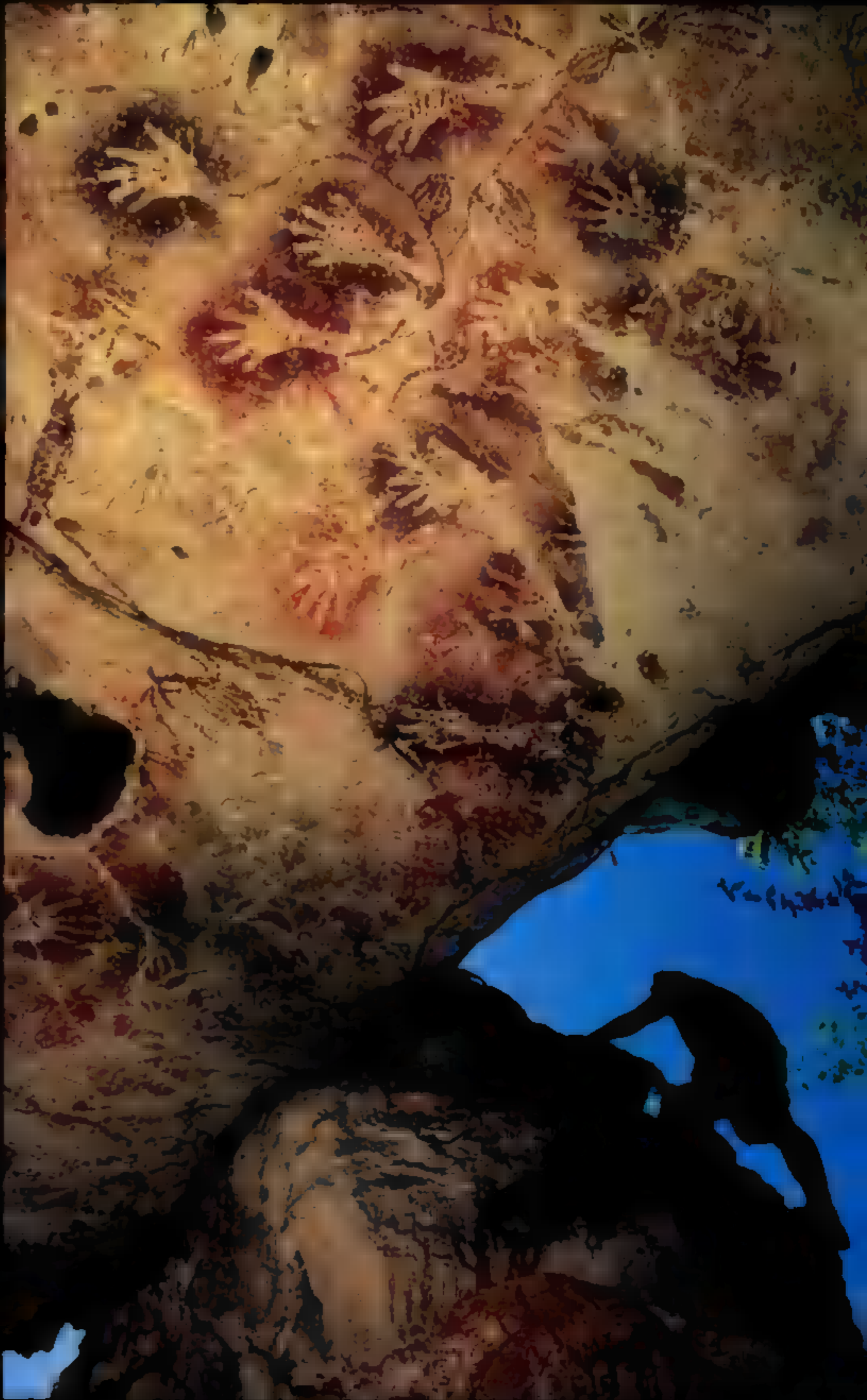
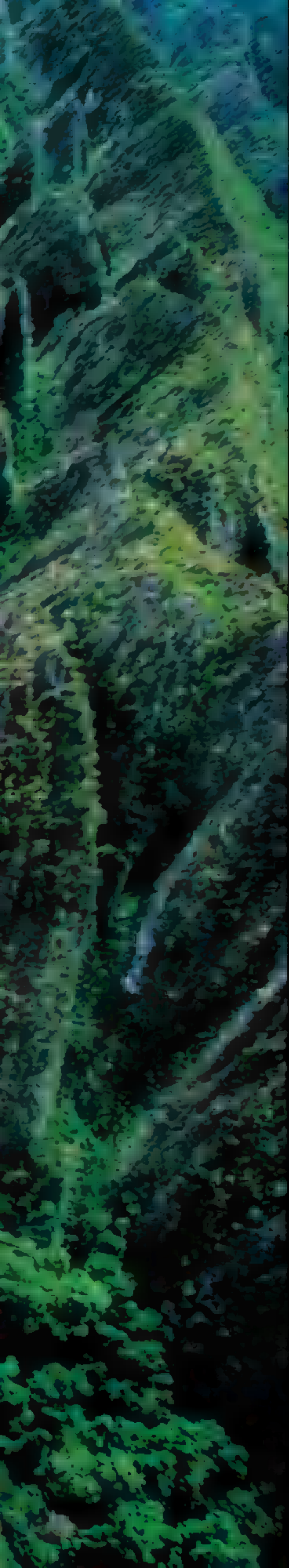












The Maiting Mountains push through the jungle, their steep sides pocked with caves. Long known by locals who visit to collect edible swifts' nests for soup, an Asian delicacy, the rock art adorns the highest caves, often on lofty ceilings indeed. The artists may have risked these climbs to prove bravery in initiation rites. Says speleologist Luc-Henri Fage, "If something goes wrong, you die."



By Luc-Henri Fage

Photographs by Carsten Peter

A few steps ahead of me on the jungle trail, my Dayak friend and guide, Ham, suddenly stopped. “Careful, Luc, a snake!” he said. The rain had fogged my glasses, but I could still make out the big bluish black cobra he’d almost stepped on. A snakebite could have been deadly, since we didn’t have any serum with us, and the closest clinic was two days behind us by foot, and another two days by boat. We stood in silence, listening to the patter of rain on the tropical forest as the cobra unfurled itself and disappeared into the bushes.

We were heading for Ilas Kenceng, the most beautiful and inaccessible of all the caves we’d discovered in Borneo. When we first saw it in 1998, we had only a few hours to study its mysterious rock art before we had to hike out, leaving us with many unanswered questions: Who made these images? When? And why? Now

we were on our way back to look for more clues.

There were 35 of us in all on our French-Indonesian team, including archaeologists, cavers, guides, a film crew, canoe paddlers, porters, and a cook. We’d begun our expedition a month before on the coast of the Makassar Strait in East Kalimantan in the Indonesian part of Borneo. Pushing off into the chocolaty Bungalun River in ten heavily laden pirogues, we’d headed for a region where there are no roads or villages, only endless jungle and jagged limestone peaks. Our plan was to follow the Bungalun to its confluence with the Marang River, then continue north into the mountains, stopping along the way to investigate a string of caves with similar rock art.

Sitting on the duckboards of my precarious little boat, its gunwales inches above the waterline, I’d thought back to my first expedition here 17 years ago. A documentary filmmaker and magazine editor, I had set out on a 700-mile trek from one end of Kalimantan to the other with







No roads link Borneo's coast with the Marang Mountains in the province of East Kalimantan, so guides muscled researchers' boats up the meandering Bungulun River (below and opposite) to reach the Marang River. The team then scaled cliffs hundreds of feet high to explore the caves.

a few caving friends. Halfway across the island, taking shelter under a rock, we found ancient charcoal drawings on the ceiling. When I returned to France, I was surprised to learn that no such rock art had ever been reported in Kalimantan.

I returned in 1992 with Jean-Michel Chazine, a French archaeologist and specialist in Oceanian prehistory. Two years later we discovered prehistoric paintings in East Kalimantan. In 1995 Pindi Setiawan, an Indonesian anthropologist, joined our team, and together, year after year, we found dozens of caves with paintings throughout the region, some with unique designs hinting at a mysterious forgotten people.

To reach our target caves this year, we followed the meandering river along the jagged peaks of the Marang Mountains. There we set up camp beside a clear spring, stringing hammocks between trees. For his dinner, our cook roasted six-inch-long scorpions, which he said were good for virility. The rest of us preferred rice. The wind kicked up just before dark, shaking leaves from the forest canopy, and a tropical storm pelted down. Once it had passed, the red ants swarmed in, their bite as painful as wasp stings. Jufri, a Bugi guide who always seemed to think of everything, drove them away by lighting just enough gasoline under our hammocks.

The next morning, back in our pirogues, we motored toward Gua



Tewet, a cave named for one of our most experienced guides. For the past 40 years, Tewet had been searching caves in the region for edible birds' nests, a delicacy in great demand at Singapore and Hong Kong restaurants catering to wealthy Chinese. Several years ago he'd remembered the cave and told us about it.

Leaving the boats at the river's edge, we hoisted our packs and scrambled up a 500-foot cliff of jagged rock to the mouth of the cave. Our muscles were burning, but the climb was worth it. The paintings inside were as breathtaking as when we'd first seen them in 1999: some 200 stenciled hands, remarkably

**SOCIETY GRANT**  
 This Expeditions Council project is supported by your Society membership.



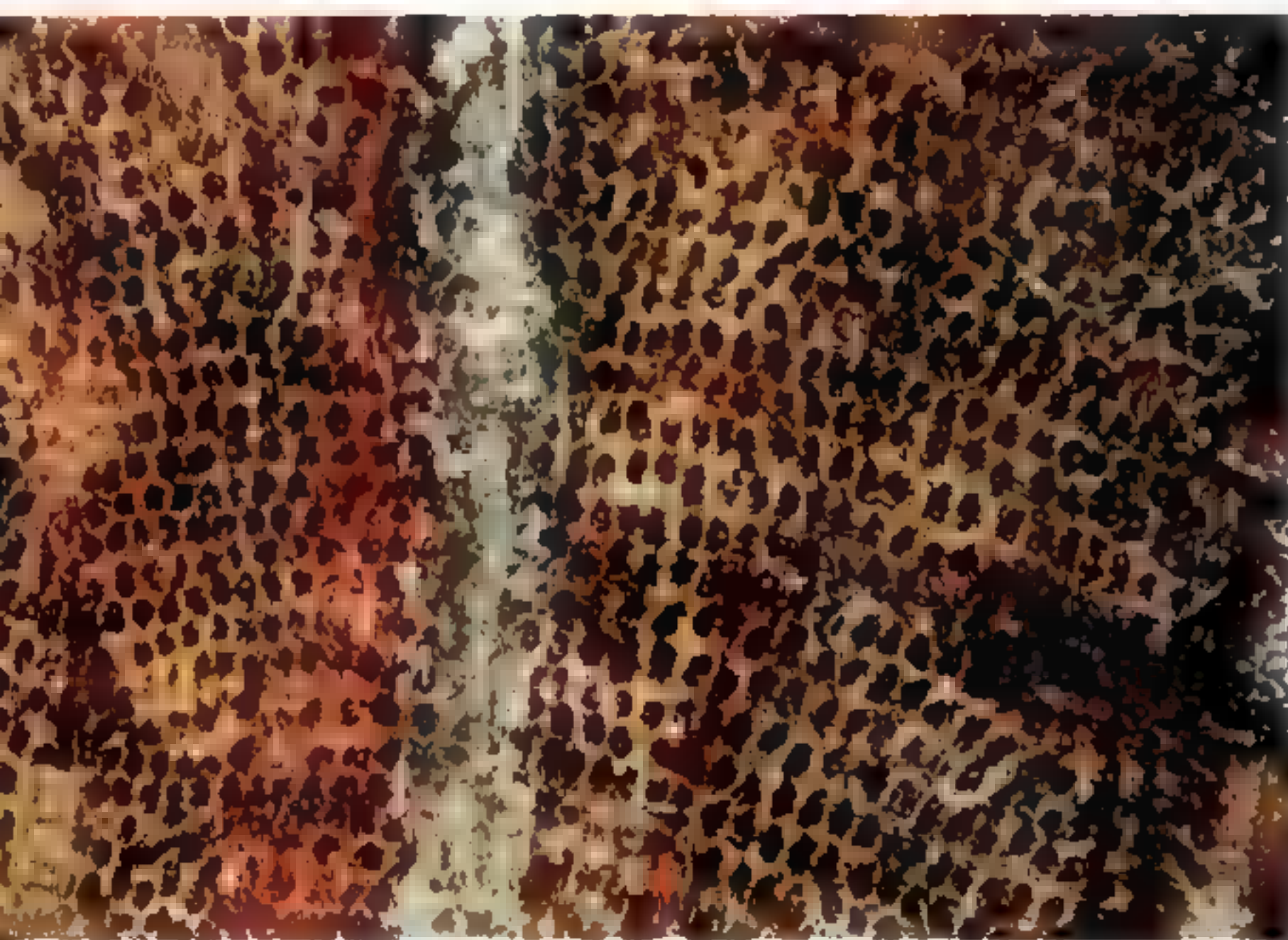
Capitoline members camped in Gua Han for five days, drinking with water collected from dripping stalactites. Archaeologist Jean-Michel Chazine believes the hunter-gatherers who stenciled the cave walls with some 350 hands retreated here alone or in small groups to fast, dance, chant, and pray.











preserved, along with drawings of animals and humans. About half the hands were covered with dots, lines, chevrons, or other patterns. I counted more than 50 combinations (see page 45).

"They look like tattoos," I said to Chazine.

"Or maybe body painting," he replied. Such practices still occur in Borneo and elsewhere to identify an individual's membership or status. At the center of the ceiling was the cave's tour de force: 11 hands, each decorated with a different pattern, linked in a design that evoked a family tree (pages 32-4). Not far away, two hands, connected by a broken line, framed the figure of a lizard, or perhaps a crocodile.

"We're dealing with shamanistic practices

**Multicolored masterpieces leap from the rock: In Ilas Kenceng cave, hands cluster in a bouquet; in Liang Karim, dots representing honeybees swarm in a hive; and in Gua Tewet (opposite) Fage sketches on a plastic sheet an unknown Ice Age animal to record its beauty, undiminished by time.**

here, I'm sure of it," Chazine said, "though I don't know what kind. This jagged line evokes passage from the harsh living world into the world of spirits, which only a shaman can enter and return from."

Chazine had not come back to Kalimantan just to marvel at such paintings, however. As an archaeologist his job was to learn who created this art and when. Until now he hadn't found any signs of occupation in the best painted caves—no pottery or animal bones from campfires. But that didn't surprise him. In his mind, a lofty eagle's nest like this was better suited for sacred rituals.

"Does one eat in a cathedral?" he asked.

Instead Chazine had chosen a cave closer to the river to excavate first. That's where he and his team went the next day. With its huge porch overlooking the water, Gua Tengkorak, or "cave of the skulls," was large enough to hold dozens of people. Indeed, ceramic funeral pots from a more recent culture had been found at the foot of one wall, along with charred human and animal bones.

For the next two weeks, Chazine, Julien Espagne,



■ French doctoral student, and Indonesian archaeologists Gunadi Mum and Nasruddin, would carefully sift through layers of earth, searching for artifacts. Two samples of charcoal were later dated back to 12,000 years ago. Such discoveries may eventually indicate that the people who left these prints and drawings were related to the Aboriginals who'd earlier migrated to Australia and created similar rock art.

Leaving the archaeologists to their excavations, I set out on foot for Ilas Kenceng, some nine miles away, with Ham, Tewet, our film team, and Serge Caillault, my caving partner. By the time we reached the cave, however, Serge had developed a bad fever. This worried me, since my friend Guillaume Artur du Plessis, had died from leptospirosis during our trek in 1988. I wanted to evacuate Serge immediately. But when the rescue helicopter arrived, the pilot at first didn't want to put down in our makeshift landing zone. Finally he did, picking up Serge, who was later diagnosed with typhoid fever and treated with antibiotics. He pulled through just fine.

Near the end of our expedition, after we'd spent many hours photographing, measuring, and documenting the paintings at Ilas Kenceng, I woke up one morning on my groundsheet in the mouth

of the cave. The forest below was bathed in a soft morning mist, monkeys were screaming, and birds swirled in circles, feeding on insects. I was exhausted, covered with dust. But I didn't want to leave. We still had so many questions.

High above me in an alcove was a magical piece of art, six hand stencils spread like a bouquet (opposite page). Each print was delicate, but together they seemed vibrant with energy as if they'd been created only moments ago. In 2000 a piece of calcite covering a hand in another part of the cave had been tested in a mass spectrometer at France's National Center for Scientific Research. It proved to be at least 10,000 years old, meaning that the hand beneath the calcite had to be even older.

Getting up from the floor, I walked back into the cave, where Jufri was boiling water for coffee. Of all the guides, only he had agreed to sleep in the cave. The rest were frightened of the ghosts said to roam such sacred places. I didn't know about ghosts, but I couldn't deny that I too was now haunted by the spirits of those who'd once painted these walls.

**EXPLORE THE MYSTERY** Zoom into ■ panoramic view of ■ 30-foot span of rock art, including the "tree of life," and examine it inch by inch ■ [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508).







# Decoding the Hands

By Jean-Michel Chazine

During the past decade we've discovered about 1,500 negative handprints in 30 caves in East Kalimantan. Most of them were found not in the lowest caves beside rivers—which we know from archaeological evidence were used as dwellings as long as 12,000 years ago—nor in the caves higher up, where we discovered bones and ceramic jars from much later funerary rites. Instead, they were mainly found in the loftiest, hardest to reach caves, leading me to believe they were probably connected to special rituals open to a limited number of participants.

As we know from studies of many cultures, such secluded, forbidden spots would be perfect for the instruction and initiation of traditional healers, or shamans, often involving fasting, dancing, singing, storytelling, the inducing of trances, or the painting of symbols. The large number of hands found in

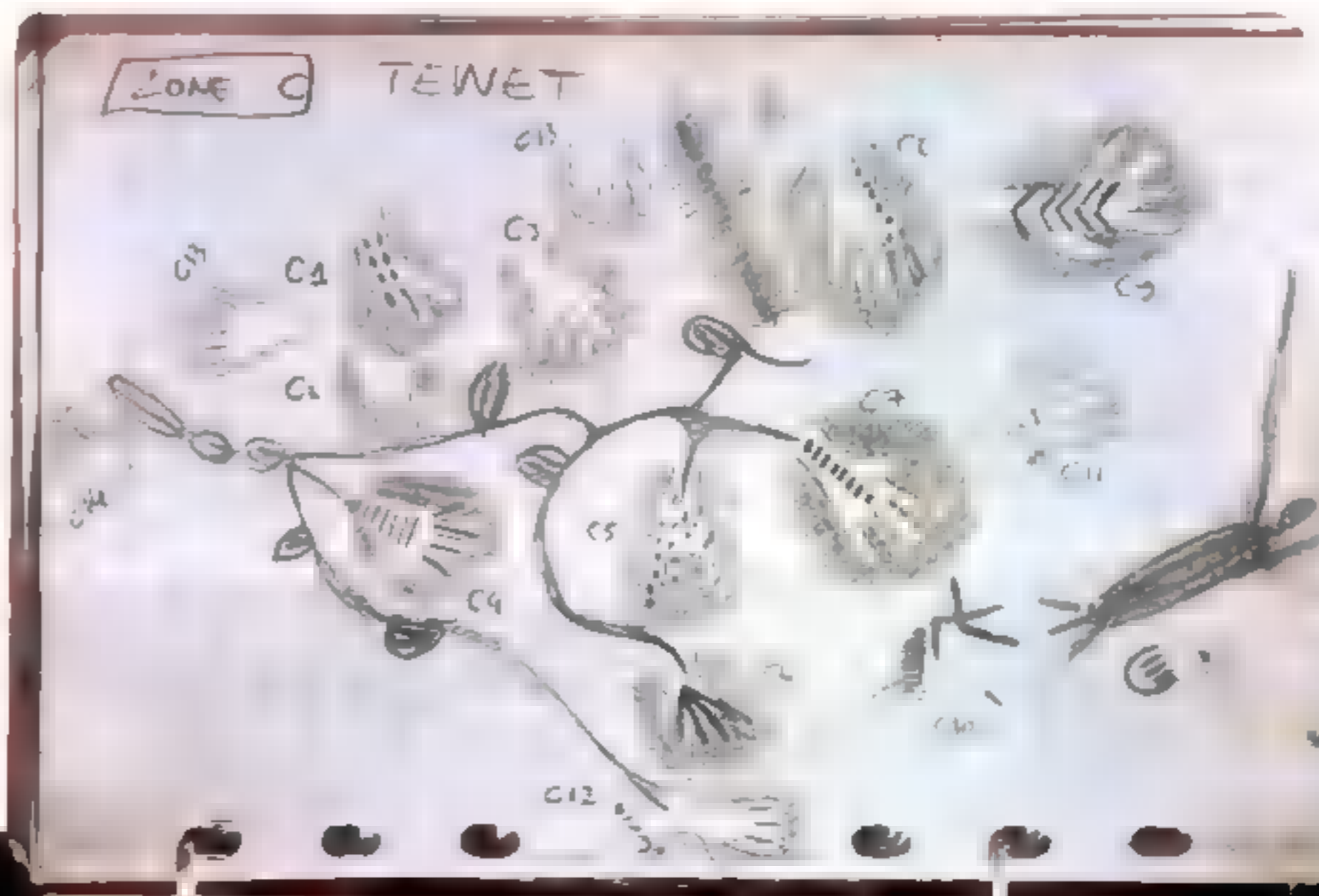
some caves may record the training of new shamans, maybe only one in each generation, over thousands of years.

Handprints are a common motif in prehistoric rock art around the world. But unlike hands discovered at sites in France, Australia, and elsewhere, many in Kalimantan caves are decorated with dots, dashes, and other patterns (opposite), the significance of which is yet unknown. In some designs the hands are linked to other hands, or to drawings of people or animals, by long curving lines. Luc-Henri Fage sketched one design (below), which we called the "tree of life," from a painting in Gua Tewet (pages 32-4, 37). This design may depict the ties that bind individuals, families, territories, or spirits to one another. A similar pattern appears in a painting from Ilas Kenceng (left), which may show a shaman's path between the world of the living and the world of spirits or of the dead, perhaps hidden behind the cave's walls.

I find a remarkable similarity between the act of creating these handprints and traditional healing practices in Borneo. To create the design, a painter would place a hand on the wall, then spray it by mouth with pulverized pigments made of ochre. A traditional healer would do much the same, laying hands on the affected part of a patient's body, then expelling his breath to spray on therapeutic ingredients. Both processes resulted in a kind of magic. □



In his notebooks Fage recorded 57 types of symbols found on hand stencils in Gua Tewet, 29 of which recurred elsewhere. "It's some form of communication code," he said. In Ilas Kenceng, double lines (above) may trace a shaman's symbolic journey as he meets a turtle and deer along his way.



NATIONAL GEOGRAPHIC PHOTOGRAPHER MARK THIESSEN (RIGHT) ART BY SHAWN GOULD (TOP) OPPOSITE)  
LUC-HENRI FAGE







# the wild

A RESILIENT MIX OF WILDLIFE AND CATTLE RANCHERS





# wet

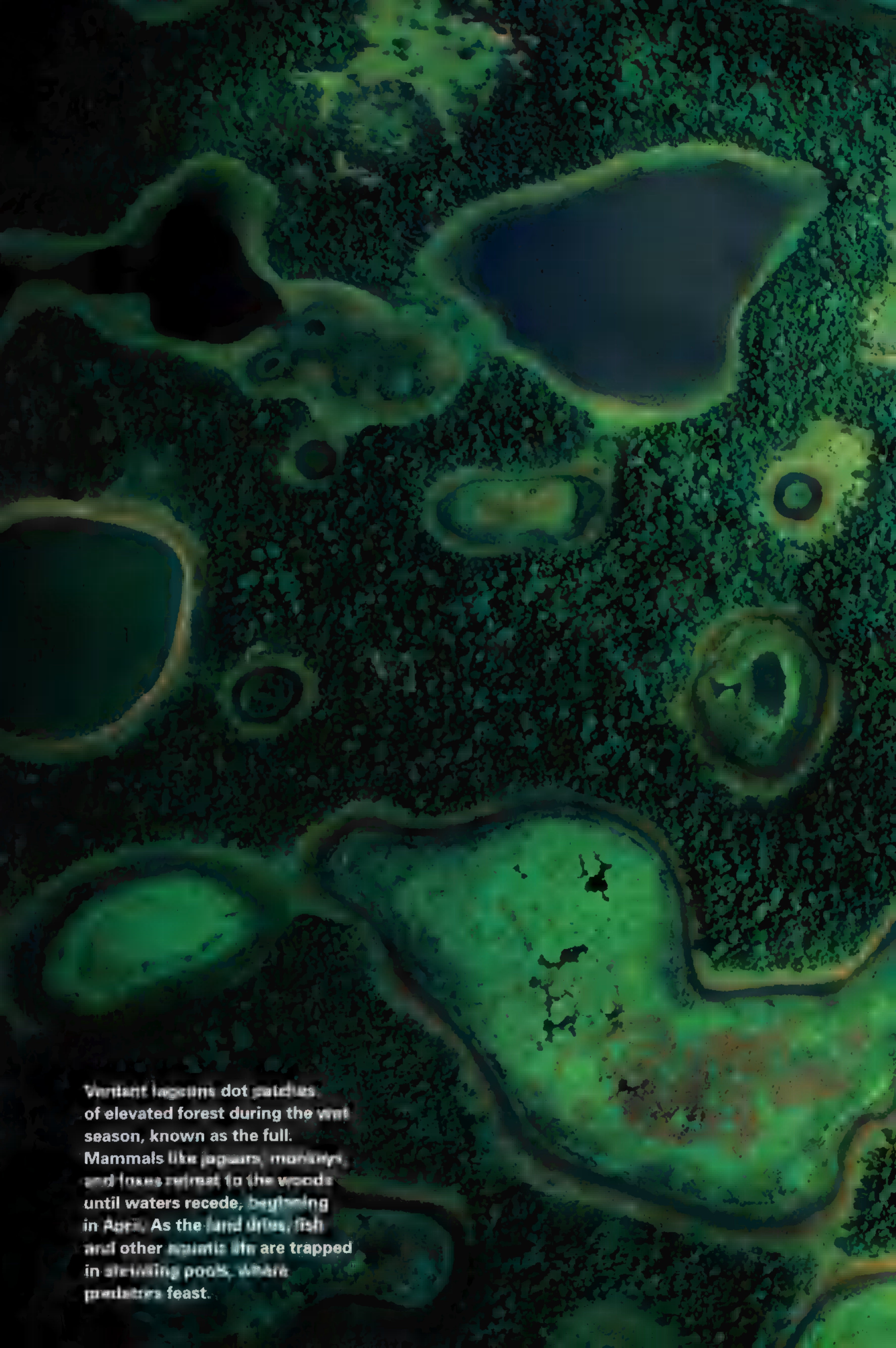
SHARE THE BRAZILIAN REALM CALLED THE PANTANAL

By Susan Mathews

Photographs by Joel Sartore

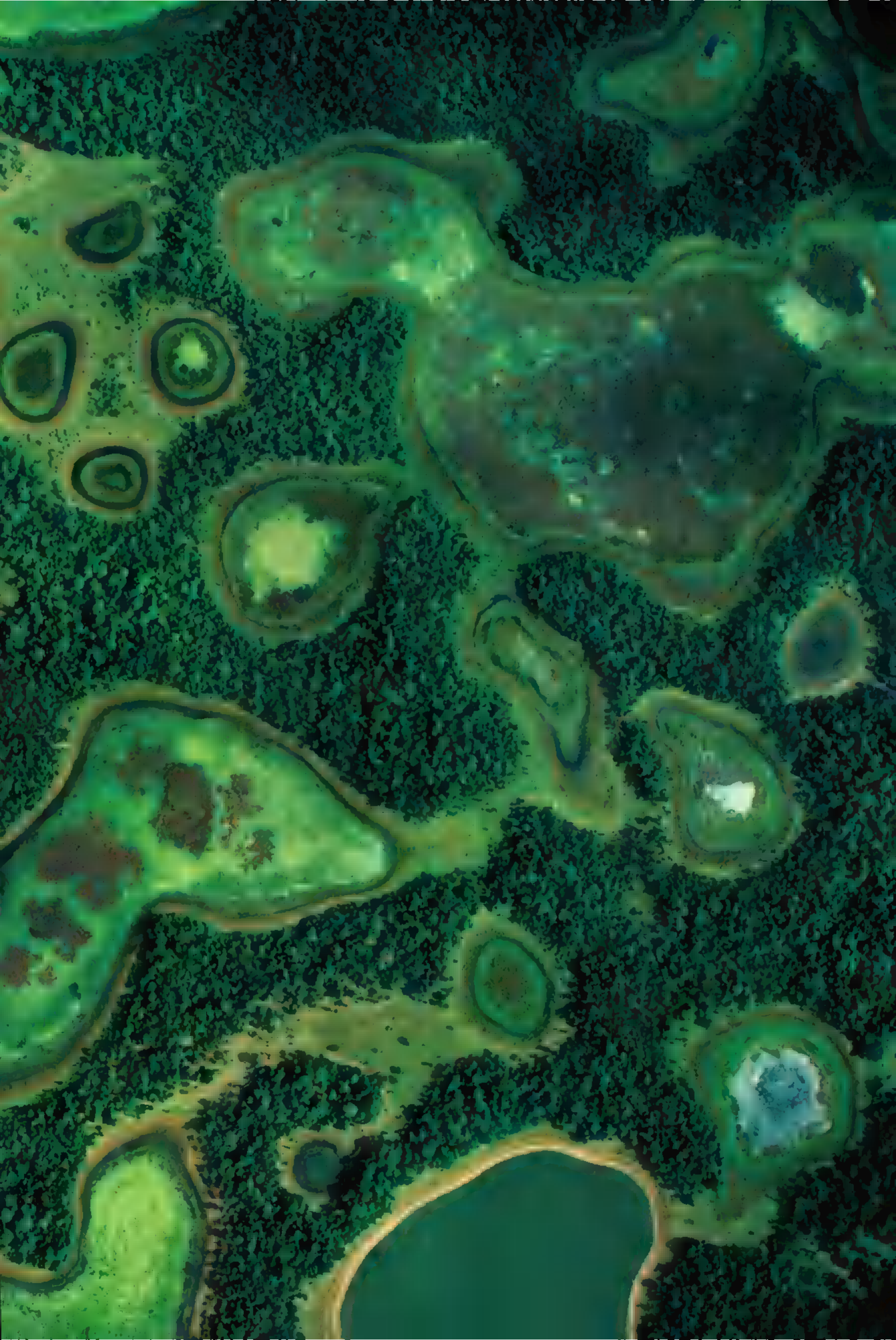
The hair-trigger jaws of a vaipian wait for bigger fish. Heavy rain from November to March swell the Paraguay River and tributaries, inundating the Pantanal—one of Earth's largest wetlands—most of which lies in Brazil.





Transient lagoons dot patches of elevated forest during the wet season, known as the full. Mammals like jaguars, monkeys, and foxes retreat to the woods until waters recede, beginning in April. As the land dries, fish and other aquatic life are trapped in shrinking pools, where predators feast.









A hunter becomes the hunted: While stalking fish stranded in swiveling waters, a great egret is seized by a yellow anaconda's crushing coils. "I could hear bones giving way in small muffled explosions as the bird was squeezed," says photographer Joel Sartore. The eight-foot snake struck at him also—but missed.

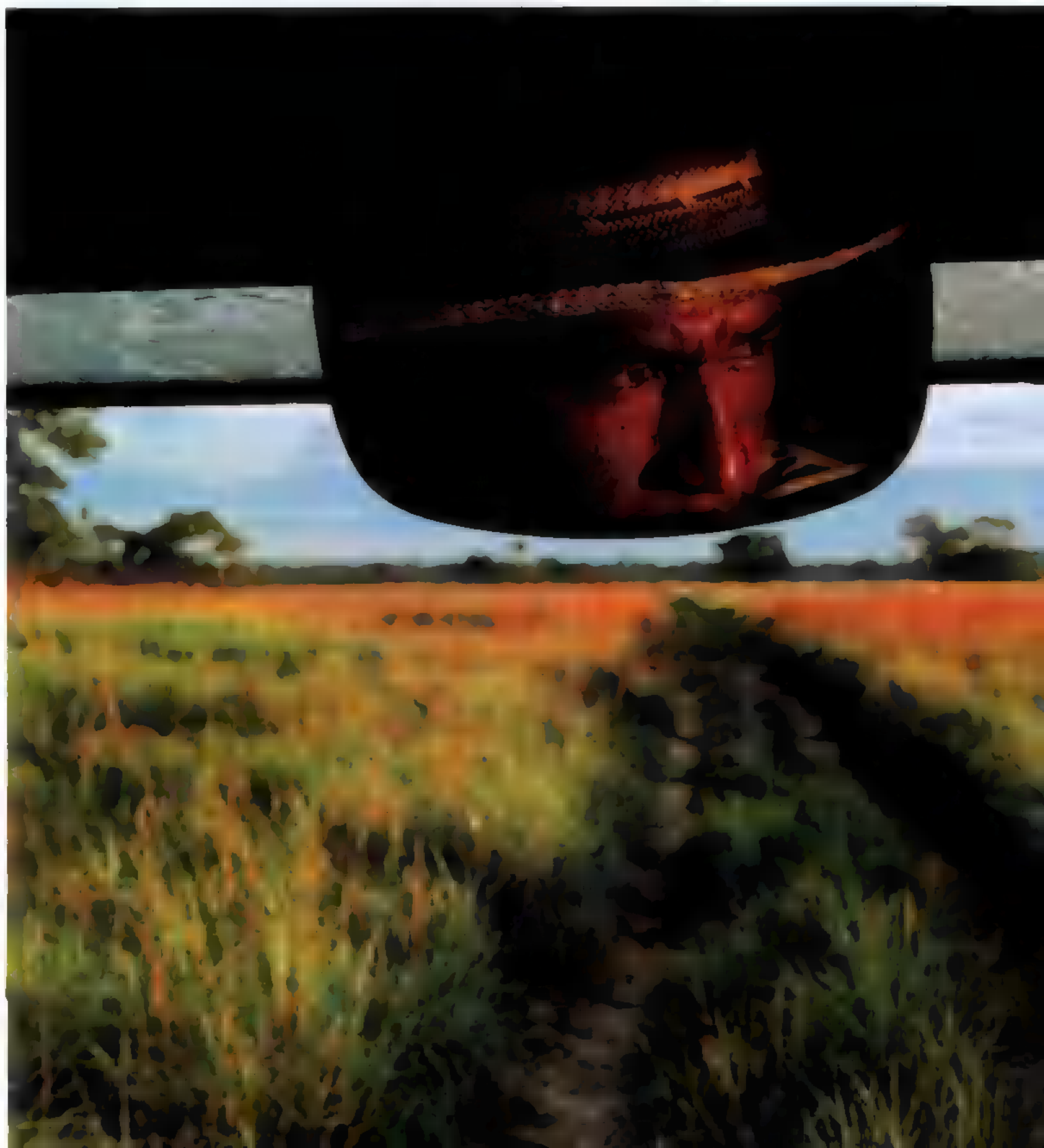






**T**he cowhands who make their living in the Pantanal wetland have an unparalleled lexicon for mud. Plain old mud is just *lama*—or *barro* or *lodo*—as it is anywhere else in Brazil. But here in the Pantanal, the bare mud where cattle gather around a gate has its own name: *maidô*. And so does deeply hoof-pocked mud with sharp ridges between the pocks: That's *brocotó*. Even the season that gives rise to all this mud has its own Pantanal name. The *cheia*, they call it, the “full,” when this whole grand wetland floods knee-deep—hip-deep, waist-deep—with water.

The mud that underlies Beatriz Rondon's ranch, the Santa Sophia, is high in clay, and though her land rolls out like a glorious tallgrass prairie in the dry

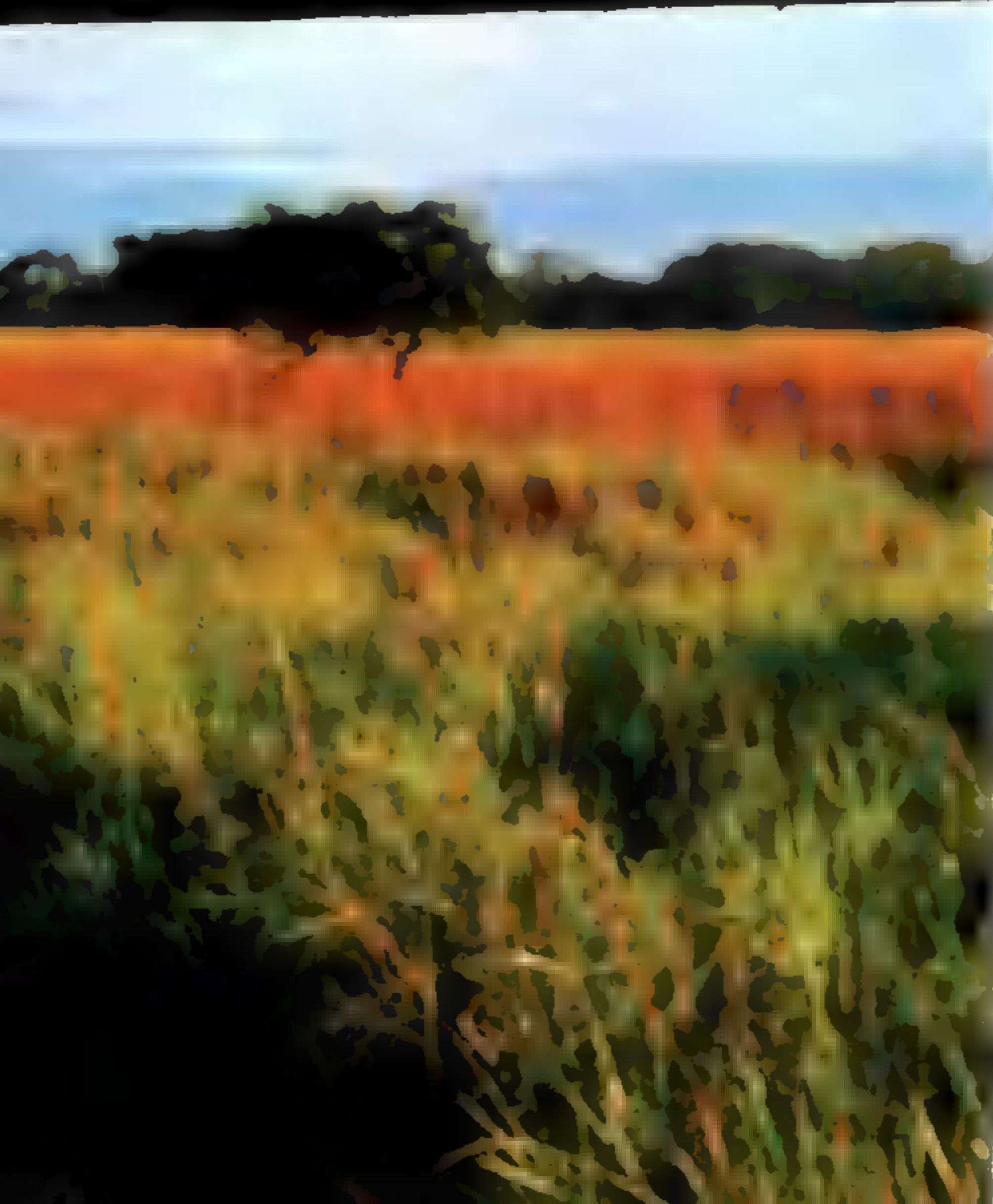




season, it turns into a diabolical, hoof-sucking bog called *brejo* in the full. Dawn finds our horses postholing through it, withers deep in gray-brown water. There are no cattle in sight, only jabiru storks and wood storks and roseate spoonbills and snail kites and, idling at the water's surface among chartreuse grasses, the ubiquitous crocodilians called caimans. My mare stumbles over one but, unlike me, shows no alarm, and the caiman simply glides away with a sidelong stare.

It's a tendon-wrenching, arduous ride, and before the parrots are done squawking the morning news from their roosts in the palms, mare and I are streaming sweat and plastered in mud—a gluey gray slurry for which no one offers a name.

Midafternoon we rein up at an elevated ribbon of forest. A pungent stink



**"I can't stand outsiders telling me what to do. But we have to go forward. The Pantanal is changing under our feet."**

**Few cattle roam the Rio Negro Ranch, where onetime cowboy Hélio Martins now spots wildlife for ecotourists. Once 692,000 acres, the ranch has been subdivided several times among heirs. Conservation International bought 19,000 acres in 1999, then removed most cattle and built a research center to study species like jaguars and giant river otters.**

**Ranchers increasingly take in ecotourists to supplement their income from cattle.**



rolls out to greet us, and two dozen vultures flap away at our approach. Our small party dismounts, and Beatriz (called Bia), her ranch foreman, Urbano Vilalba, two cowhands, a naturalist named Marion Marcondes, and I follow our noses into the gloom of the woods.

The carcass has been dragged 25 yards from where Urbano found it yesterday, his attention drawn by circling vultures while out here shifting cattle around. Now it lies half submerged at the edge of the bog, bloated, discolored, and twitching with maggots. Two days ago it was a regal, cream-colored, long-horned, half-ton, humpbacked zebu bull worth \$400 at current beef prices. Today it's jaguar kill.

That a jaguar has dined on bull is not a particularly noteworthy event in the Pantanal. Typically vultures alert the rancher, the rancher calls in a professional jaguar hunter, the hunter tracks the cat with a pack of scarred hounds, shoots it, and leaves the carcass for scavengers. Even though jaguar hunting is illegal in Brazil, it's still common in this remote, largely unpeopled realm. As a jaguar hunter put it to me: "Who's to know?"

There will be no jaguar hunter this time. Bia has signed a contract with a nonprofit conservation group trying to preserve the threatened cats in the Pantanal. Naturalist Marion Marcondes has ridden out here to verify that a jaguar killed one of Bia's bulls. She'll file a report, and Bia will be reimbursed—"partially reimbursed," Bia notes dryly—for her loss. In return Bia will let the jaguar live.

"I adore jaguar hunting," says Bia, 64, whose grandfather staked an enormous land claim here in 1892. "And I can't stand outsiders telling me what to do. But we have to go forward. The Pantanal is changing under our feet. Like it or not, we Pantaneiros have to change too."

**L**ying far south of the Amazon, the Pantanal is a lopsided, 74,000-square-mile wetland within the Upper Paraguay River Basin, where the borders of Brazil, Paraguay, and Bolivia meet. It's one of the world's largest wetlands—an area more than a third the size of France. The name translates loosely as "big swampy place," *pântano* being the Portuguese word for swamp, but the Pantanal is really an alluvial plain, one so nearly flat that rainwater just loafs across it, flooding it in the full season, draining away in the dry.

**"You need a lot of land to raise cattle if three-quarters of it is going to be underwater [part of] every year. The man of the Pantanal learned early on that he couldn't fight the full."**

**Land becomes lake in March ■ pastures flood on Barra Mansa Ranch and stingrays ride the overflow of the nearby Rio Negro. By late August the rays have retreated with the floodwaters, and horses stand on the same spot—sandy, barren, and bone-dry.**









Rain begins saturating the ground about November, and gradually the water starts to rise. The Paraguay River and tributaries swell and overflow, so that in January, February, and March—in a really full year—only the winding gallery forests called *cordilheiras* and the round, hummocky forests called *capôes* and the earth that humans have scraped into dikes and mounds are dry land. The rest is damp or muddy or wet or flooded in various degrees. Wading birds, caimans, fish, and semiaquatic mammals like tapirs and capybaras disperse across the flooded land. Animals that like to keep their feet dry—jaguars, ocelots, crab-eating foxes, deer (and often cattle)—crowd into the narrow forests and make do till the waters subside.

In the dry season, roughly May through September, the water withdraws into its riverbeds and shrinks into rounded, puddle-like ponds called *baías*, and the whole marsh is transformed into a tawny savanna. Wading birds throng the shrinking *baías* and sloughs, gorging on stranded fish. When the seasonal ponds dry up and the last fish are gone, the birds retreat to the forested rivers and streams.

It's an improbably soggy place for ranching. But since the late 19th century the Pantanal has been given over to immense cattle ranches, called *fazendas* in Brazil, so lightly placed on the landscape they look more like wildlife refuges than ranches. It's a style of cattle ranching imposed by the sharp extremes of the wet and dry seasons—and that serendipitously has protected this extraordinary ecosystem.

As wetlands all over the world have been degraded and destroyed, the Pantanal, its abundant wildlife, and its distinctive ranching culture have survived into the present relatively intact, insulated by the annual floods and the near-feudal distribution of land. Fiefdoms of half a million acres were once common and still exist today. Bia Rondon doesn't think Santa Sophia's more than 85,000 acres is much to boast of; her grandfather's ranch, Fazenda Rio Negro, once sprawled over 692,000 acres.

"You need a lot of land to raise cattle if three-quarters of it is going to be underwater three months out of every year," one Pantaneiro explained. "And you won't bother undertaking extensive alterations—roads and dikes and buildings. The full season's just going to wash them away, if not this year, surely the next. The

man of the Pantanal learned early on that he couldn't fight the full."

But the insulation of the full may no longer provide sufficient protection. Industrial soybean and cotton plantations increasingly dominate the highlands north and east of the Pantanal, drizzling damaging sediment and herbicides and fertilizers downstream into the floodplain. Their owners and the multinational corporations they supply exert relentless pressure on the governments of Brazil, Paraguay, and Bolivia to deepen the Paraguay River for oceangoing tankers and to build an all-season highway to speed their goods to market. These big infrastructure projects, many believe, would be catastrophic for the fragile hydraulics of the Pantanal.

Beef prices have fallen as cattle ranching expands elsewhere in Brazil, pulling the Pantanal

**Few roads slice the soggy Pantanal, a floodplain half the size of Montana. Its 74,000 square miles in three nations are nearly all privately owned. Brazil's constitution calls it ■ national treasure.**





standard of living down with them. And the grand old ranches are being whittled away by what Brazilians wryly call “familial agrarian reform”—divided among heirs with every passing generation until the individual slivers are too small to provide a living. Too small, that is, unless you clear the forests on elevated ground. The incentive to clear is high: The more all-season pasture you own, the more cattle you can graze year-round. But it’s a blow to the wildlife that looks to these forests for food and shelter, and in the long term it’s a cause of erosion that could lead to permanent flooding.

Even ecotourism, which now supplements the income of many ranchers, is seen as a mixed blessing: outsiders encroaching on what has felt like a private world. “You can’t go 15 miles anymore without running across somebody,” an old hand grouched to me.

Many Pantaneiros feel their way of life is under siege. “We’ve been good stewards,” says Bia Rondon. “People come from all over the world to see our wildlife. But a way of life we’ve taken for granted can no longer be taken for granted. Ranching works for nature in the Pantanal. We have to find a way to make ranching keep working for the Pantaneiros. Otherwise the Pantanal as we know it will not survive.”

**W**hat does it take to ranch cattle during the Pantanal full? “It’s hard work, grueling work. Your feet are wet every day—day after day,” says a seasoned cowhand who started wrangling at 13. “But your spirit would die if you weren’t out in the open with the long, beautiful view.”

Before the regenerating waters arrive, fazenda owners send as much as a third of their stock to market, or risk losing them to starvation or drowning. From the most remote ranches, cattle drives can take nearly a month to reach the nearest earthen highway, where the herds are loaded onto trucks. Tending the cattle left on the land during the full season falls to men who think of themselves as “amphibious cowboys.”

It’s a lousy day to be messing with cattle the morning I head out with the men on a ranch called Santa Marta. There’s an intermittent drizzle. Overnight the temperature had swan-dived 30 notches to 65°F as a cold front swept through. But twice a week, full season or dry, the Santa Marta hands round up as many of the ranch’s

3,000 or so cattle as they can muster, give them salt, treat wounds, and mark any new calves. It being the height of the full, Santa Marta is mostly underwater—clear, sweet-smelling, tea-colored water. It streams across the pastures and obliterates the tracks, drowns the fences, and swallows up the gates. The ponds are underwater and so are the creeks, and even the rivers are just faster water flowing through the slower, flower-filled water.

“It’s all one water now,” the cowboys say, though they can’t resist pointing out inundated landmarks as we ride through them. I’d settle for seeing my own stirrups, struggling to lift a sodden boot wreathed in marshy greenery.

Santa Marta—at nearly 15,000 acres a modest ranch by Pantanal standards—belongs to the family of Ladislau da Rosa Lopes, a rancher known to all as Lau. Short, slim but barrel-chested, Lau, 53, is not much for talking, but he’s quick with a warming smile. I’d heard it said that a “Pantaneiro is a conservationist by temperament and by love of the Pantanal.” That, unabashedly, is Lau. We were never out with the cattle that he didn’t make sure I noticed the natives: a marsh deer, a Muscovy duck and ducklings, a pair of hyacinth macaws crossing the sky. “We like to see our wild beasts roaming free,” he says.

Lau’s ranch is no treacherous brejo patch, like Bia’s, but a firm-bottom floodplain called *vazante*—a vast, slowly moving sheet of water during the full, crowded with water lettuce, water lily, water hyacinth, and by the looks of it most of the other 250 water plants of the Pantanal. Strips of forest run through it like ancient hedgerows bordering a greensward. On a hot day the sloe-eyed zebu cattle would be grazing in this watery salad alongside the wildlife. In this morning’s dismal weather they’re hunkered down in the forests.

Six cowhands fan out across the *vazante* in pairs. Lau leads a packhorse piled with gunny-sacks of salt, occasionally lifting his corkscrewed cow-horn trumpet and giving a mournful blast to summon the herd. “I treat my cattle gently, so they stay very tame,” he says as we ride. “I don’t let the cowboys lasso them for kicks, and I don’t let the dogs chase them.”

Anticipating their salt rations, a couple hundred zebu are already waiting when Lau and I arrive at a high patch of green mud on the edge of a forest. Before long we hear men whoop from



Ranch hands rest after driving cattle from marsh to higher pasture on Caiman Ranch, first in the Pantanal to offer ecotourism. There is "a tough and lonely life," says Marina Cruz, a former ranch guide. During long days of toil they're alert for jaguars, which prey on cattle and panic horses.









a forest to the east, and a small herd of cattle trots down into the marsh. More whoops, and another slow river of cattle moves in from the west. Now a cascade from the south, and the sound of hundreds of scimitar-horned beasts slowly surging through the water is as thunderous as Iguacu Falls.

While the well-mannered zebu take their turns at the salt troughs, the riders drift silently through the lowing herd, stalking a waifish calf, a creature so slight, so light on its hooves, it looks like a marionette. *Whap!* Lassos drop over its head. The men spring from their saddles, and two of them tumble the calf to the mud. One pins it with a knee, slides a long knife from the scabbard at the small of his back, and slices two scarlet notches in a white velvet ear, to mark it as belonging to Lau. He wipes the bloody blade clean on the calf's snowy flank. The second man swabs the bleeding notches and the lingering umbilical cord with a disinfectant. A third jabs a vermicide into the calf's neck, then they're up and on to the next.

Six more calves and the job is finished, man and beast coated in mud. This afternoon they'll repeat the morning's performance at the upstream roundup. Tonight eight pairs of boots will be propped by the ranch house stove to dry. This being the Pantanal, the boots won't actually *dry* until the dry season arrives.

**L**au's house and corral at Santa Marta occupy the center of a hundred-acre island of high ground. There is no electricity. Two big tables, four benches, a couple of wire porch chairs, and some beds are the only furniture. The kitchen, roofed but open on two sides, harbors a ragtag collection of hard-luck cases: three motherless guinea chicks, a blind rooster, two skittish cats. A mob of at least 25 monk parakeets has constructed a haystack apartment in a tree ten feet from the table, and every hour they erupt in raucous quarreling. Parrots, macaws, and toucans frequent the yard too, their flashes of color and their chuckling trills and calls are intrinsic ornaments of Pantaneiro life. "They live around the house because it's safe from predators," Lau says, surveying a pair of toucans in a mulberry tree with proprietary pride.

Pantaneiros say, "It's the eye of the owner that fattens the calf." Even so, Lau and his wife, Zenilda, like many fazendeiros, don't live at the

**"Taking action to preserve only the floodplain is a waste of time if we don't save the uplands, for only one reason—water flows downhill."**

**In a cloud of dust on the Pantanal's surrounding highlands, tractors plow land yielding cotton and soybeans for global agribusinesses. Annual rains don't flood the highlands but sweep down tons of silt and pesticides. Also pouring in: tourist buses. This one packed with Brazilian fishermen splintered one of the hundred-plus wooden bridges on the Transpantaneira Highway, a 90-mile-long dirt road.**









Braving a head of grass to line its nest, a jabiru stork floats back to join its mate and chick. With an eight-foot wingspan, these year-round residents are among the more than 400 bird species sustained by the Pantanal, which is one major flyways.










ranch full-time. They spend part of each month a hundred miles south in Aquidauana, the cow town on the southern edge of the Pantanal where many ranchers in this corner of the wetland keep a house and buy supplies. Lau's brother Jopei or a hired hand runs Santa Marta in their absence. Bigger ranches, like Santa Sophia, employ a foreman to manage operations. Really big ranches may also subdivide the property and station a cowhand and his family in a house called a *retiro* to oversee an outlying spread.

During the 15-hour, four-wheel-drive trip that had brought me from Aquidauana to Santa Marta, Lau stopped his truck at one of these simple plank *retiros* on a neighbor's ranch. It was late afternoon. A man named Clemente and his wife, who was never introduced, sat at a table on the veranda, he splicing strands into a raw leather lariat that looked to be 30 feet long. Their teenage son, shirtless, in battered chaps, perched on the low veranda wall. His 13-year-old sister rocked in a hammock. Chickens scratched at the swept dirt yard. Two horses dozed at a hitching post, dressed in high Pantaneiro style: shiny metal rings laced together into bridles and chest ornaments; cushy vermilion sheepskin saddle blankets topped with a square of tooled leather.

Clemente asked if we'd accept some *tereré*, a kind of cold maté tea, equal parts ceremony and caffeine fix with which Pantaneiros punctuate their day. His wife fetched the worn cow-horn cup packed with green, grassy-tasting maté leaves, the metal straw with its bulbous strainer, and a plastic pipkin of water. Clemente filled the cup and passed it to each of us in turn. Etiquette requires the drinker to drain the cup with a last, hard, audible pull on the straw before passing it back to the host. He refills it and passes it on to the next.

As Lau and I left, I asked what the children of cowhands do out here. "That boy's been a salaried cowboy since he was 11," he said. And the girl? Lau sighed. "A 13-year-old girl we know was married this summer. It's not unusual. They have nothing else to do. There's no school out here. There are no jobs for women. Their mother nags them: Wash the clothes! Their father nags them: Sweep the yard! Marrying and being independent and having their own house starts to look good—even at 13.

"The boys, 14, 15, 16, well, they're accustomed to visiting women of the street when they go



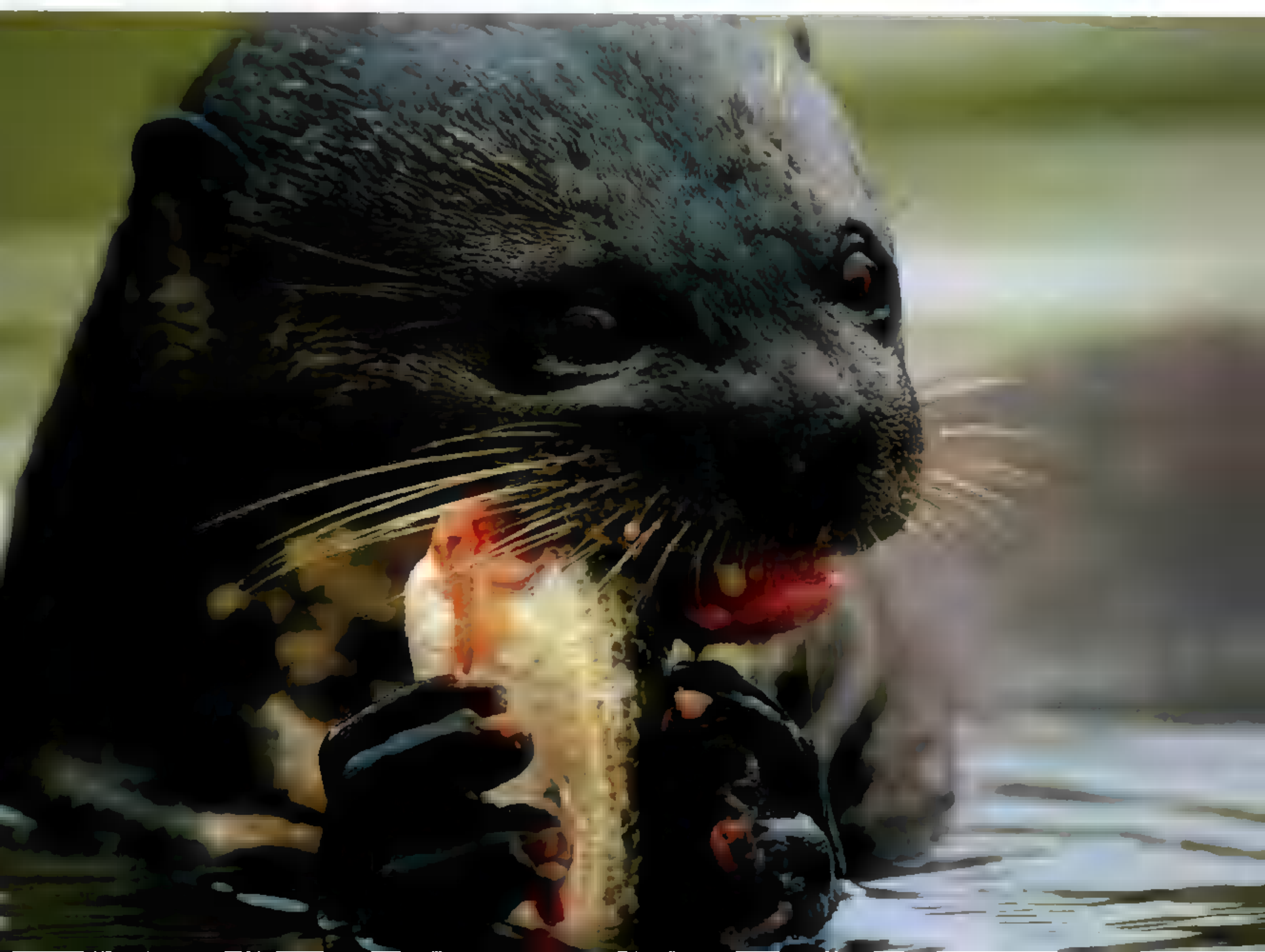
It took an outright war on wildlife to bring the Pantanal to the world's notice.

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The wet season yields ■ finny crop in a flooded forest on Barra Mansa Ranch, where ■ worker snagged ■ dourado, a prized food and game fish. Tens of thousands of subsistence and sport fishermen ply the Pantanal's waters, which brim with at least 325 kinds of fish. Those fish nourish other animals such as the giant river otter (right), now on the rebound after nearly being wiped out by poachers.









to town. So they start to think, Why not save money, marry a woman of my own? Everything happens earlier here in the Pantanal."

We drove on through ever deepening mud, the landscape becoming more open, the water rising, until finally waterlogged grassland became *vazante*. In slowly falling light, Lau parked the truck under a lone tree, turned to me, and bowed. "Madam, your ride on wheels is over." We transferred supplies and sacks of food to a light aluminum skiff pulled up in the reeds.

Lau's brother Jopei and son had paralleled us with a string of horses to be returned to Santa Marta. Lau lashed the bowline of the skiff to Jopei's saddle, we clambered aboard, and for an hour and a half were towed serenely across the marsh-meadow in the one-horse-power pleasure barge. Isolated thunderheads painted the broad sky here and there with rain. A river of egrets poured away from us homeward low across the sky. The string of horses splashed ahead. In the last horizontal shafts of light, a full double rainbow appeared in the east.

This is the Pantanal that Lau cannot bear to think would disappear. But he sees disquieting signs. Deforestation for agriculture near the headwaters of the Rio Negro is causing silt buildup in the river. "The government permits it to happen," he says. "It makes a person feel very small, very helpless."

I saw that forests had been razed in this part of the Pantanal too, on fazendas with absentee owners, not native Pantaneiros, who are replacing trees with non-native grass to create year-round pasture. "People are cramming more cattle onto the land," Lau says. "What will happen to the animals who live in those forests? The grazers will be all right; they'll stick around. But the animals that eat fruit and palm nuts—the parrots, the monkeys—they'll move on. They'll move to my ranch, I guess."

**I**t took an outright war on wildlife to bring the Pantanal to the world's notice and create a better understanding in Brazil itself of the wetland's ecological importance.

Commercial hunting of wildlife became illegal in Brazil in 1967, but the law lacked teeth and the fines were slight. When caiman poachers set their sights on the Pantanal, little stood in their way. Starting in the late 1970s, most of the world's crocodile-skin fashion accessories for the mass

market were made from skins stripped from caimans right here in the Pantanal.

Pairs of hunters called *coureiros*—from *couro*, or leather—punted the shallows by night, locating caimans by their distinctive eyeshine and shooting them between the eyes. By day the *coureiros* retreated to the woods to salt the skins, leaving rotting carcasses stacked hundreds deep. Their take may have reached as high as a million caiman skins a year. Vultures and the stench of carrion drifted over the marsh like a pall.

"The main trade was caimans, but they took whatever they came across," a cowhand who found himself in the thick of it told me. "Ocelots, otters, jaguars, anacondas." The skin trade spawned traffic in live animals for the exotic pet market. Ten thousand hyacinth macaws were stripped from the Pantanal during the 1980s alone. Along with giant otters, they all but disappeared. Only the sheer number of caimans—millions upon millions—kept them from being wiped out.

Lau's Fazenda Santa Marta proved too remote for the *coureiros*, but Bia Rondon's Santa Sophia was sacked for its wildlife, as were other ranches along the more accessible stretch of the Rio Negro closer to Aquidauana.

"The Pantanal was a battleground," says Bia. "No one dared leave the house. Employees fled. My relatives and I tried to get the local police to expel the trespassers, but even the local police were in on the business."

Desperate, Bia and a small group of relatives and neighbors took matters into their own hands in 1984. Calling themselves SODEPAN—Society for the Defense of the Pantanal—they sold 20 heifers each and pooled the money to pay for gas, munitions, and bush planes to fly police in from the city. In their battle against the *coureiros*, Bia and her siblings received death threats; families took refuge in São Paulo; *coureiros*, cowboys, and police were shot, some killed.

A reporter from a São Paulo newspaper infiltrated the trade. His shocking reports of a Pantanal plundered of its wildlife, uncontrolled trafficking that eventually extended to marijuana, cocaine, probably arms, and evidence of involvement by the Bolivian and Paraguayan military, attracted worldwide attention.

Bowing to pressure, Brazil created a special forestry police in 1986, and in 1988 strengthened its law against the hunting of wildlife. With



armed patrols turning up the heat, fewer coureiros found the risk worth the price they got for skins, about two dollars. When a 1992 resolution by the Convention on International Trade in Endangered Species banned the export of raw or salted skins—the only processing poachers could manage in the field—the coureiro wars were finally over, and with them the wholesale liquidation of wildlife in the Pantanal.

**B**ut even as the coureiro wars were raging, other factors were coming into play that would launch permanent, long-term changes in the Pantaneiro way of life.

In 1974 a historic flood caught owners unprepared; tens of thousands of cattle drowned, and every fazenda suffered losses. Some lost everything. In the following decades, the full season continued to run ruinously high.

Also in the mid-seventies, the Brazilian government gave away land in the country's interior highlands to populate the central-west and to ease pressure on the Amazon rain forest. The new farms proved more lucrative than the floodplain of the Pantanal. Whereas Lau needs more than five acres for every cow and Bia needs seven, the new farms, with year-round grazing, can put a cow on every acre. With more Brazilian cattle coming to market, beef prices tumbled.

More threatening, "a huge amount of change is occurring in the highlands north and east of the Brazilian side of the Pantanal," says Carlos André Bulhões Mendes, a professor in the water resources and environmental planning institute of the Federal University of Rio Grande do Sul. "You see the full spectrum of development ringing the Pantanal—cities with inadequate sewage treatment; chemical-intensive soybean, sugarcane, and cotton plantations; intensive ranching. There is a growing awareness that taking action to preserve only the floodplain is a waste of time if we don't save the uplands, for only one reason—water flows downhill."

The worst damage can be seen in the highlands along the upper Rio Taquari, far northeast of the Rio Negro, where Santa Sophia and Santa Marta lie. Clearing, tilling, and grazing this sandy ground has created a 5,000-square-mile lunar-scape of gullies and ravines. It has hemorrhaged so much silt downstream that part of the Taquari riverbed has filled up, permanently flooding some

4,000 square miles of the Pantanal. The immense shallow lake no longer supports wildlife, nor can it be farmed. A hundred small farms and 20 big ranches there now lie abandoned.

"The Brazilian government, the Organization of American States, and a coalition of environmental groups have together undertaken a lot of work to stop the erosion, with barely noticeable results," Carlos André says. "There's even been talk of dredging the lower Taquari to remove the sediment. But that would be going after the effect rather than the cause. Unfortunately, it's not a solution."

Shocked into action, Bia and other politically active landowners are pooling their considerable clout to fight for protection of the headwaters of other rivers that flow into the Pantanal, before these go the way of the Taquari. They're building coalitions, overcoming their deep-seated disdain for the meddling of outsiders. Working with national and international environmental organizations, they helped stall a grandiose plan, known as the Hidrovia, to deepen and straighten the Paraguay River and provide year-round passage for big cargo barges. But now they find themselves going head-to-head with other powerful constituencies—the soybean, sugarcane, and cotton industries—and no one doubts that some scaled-back version of the Hidrovia will eventually be put into place.

"Infrastructure improvements can bring economic benefit to the country," Carlos André says, "and there's a lot of poverty in Brazil. But the engineering must be very carefully undertaken to minimize environmental impact in the Pantanal. Tremendous damage could be done."

Bia lies awake in the small hours sometimes, thinking of little else. "The horror of it for those of us so tied to this terrible and marvelous land, you simply can't imagine."

**M**ore immediate worries than the health of the greater Pantanal contribute to Bia's sleepless nights. Keeping her own ranch viable in the current beef market is no sure thing. It would shock her forebears, but Bia has diversified into ecotourism. The black-and-gold icon of the Pantanal—the jaguar—plays a key role in her plans.

Bia loses at least four head of cattle a month to the big cats; in a lean year they can rip the throat out of her slim profit margin. But on



Ten million caimans in need.  
Pantanal waters—so many that  
their numbers stayed healthy even  
when an army of poachers claimed  
perhaps a million a year during the  
1980s. The hides supplied the  
market for inexpensive crocodile-  
skin accessories. Until ranchers  
battled poachers and feared for  
their land and their lives.



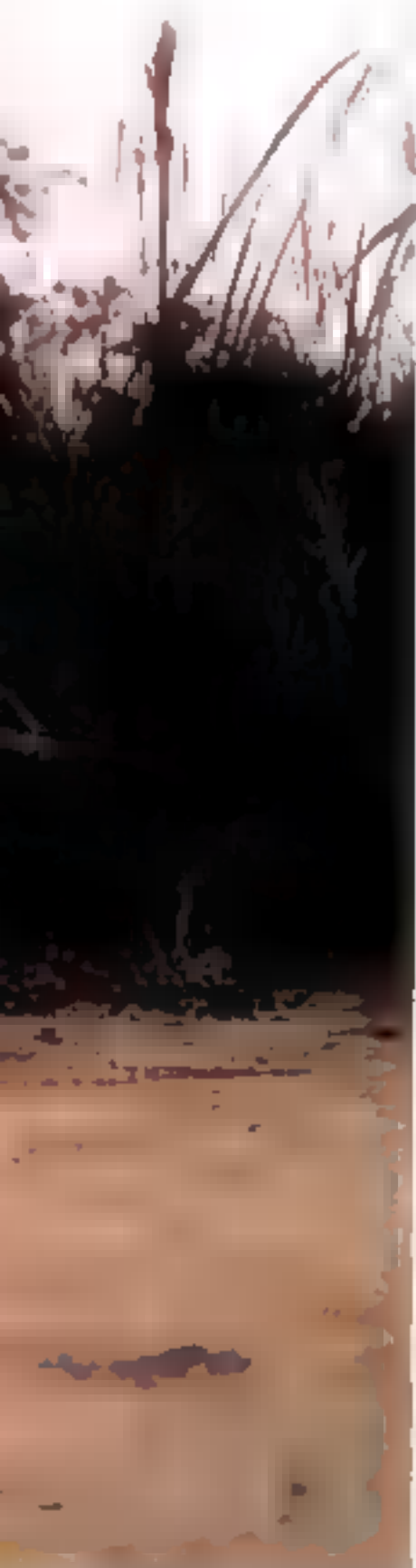












**"We've been good stewards. People come from all over the world to see our wildlife. But a way of life we've taken for granted can no longer be taken for granted."**

**Orphaned by a fence that ensnared its mother, a young anteater drinks a bottle of milk offered by a worker on Pouso Alegre Ranch (left). Anteaters thrive on the Pantanal's savannas, as does South America's largest canine, the maned wolf (top). Long legs boost the perch of its ultrasensitive ears for detecting prey in tall grass. As the outside world encroaches on the Pantanal, its wildlife and the ranchers who have minded the wetland for generations may all need a leg up.**

the day we examined the eviscerated fat bull at the edge of the brejo, Bia was not bitter. "Ecotourism," she said, "is turning my jaguars into a tourist commodity."

Ecotourism may indeed be the future of the Pantanal, providing ranchers with needed cash and reducing the temptation to squeeze a little more out of the land. For the cowhands' wives and daughters it creates jobs, otherwise rare for women. It's an incentive to preserve habitat for wildlife. And it helps keep ranchers from killing jaguars.

The chance to glimpse a jaguar is a big draw for tourists, whether they're budget backpackers or the high-end adventure travelers Bia caters to. Since Bia swore off hunting in 2003 as part of the jaguar-kill reimbursement project, the elusive cats seem more willing to show themselves. One sunny afternoon at her ranch, a pregnant female lingered in the Rio Negro for 15 minutes in full view of a delighted group of paying picnickers.

How many jaguars are left in the Pantanal is anyone's guess, according to Fernando Azevedo, a biologist studying jaguar predation on cattle. "They're solitary, nocturnal, very secretive. No one knows if their population is holding its own or shrinking or growing. All we can say for sure is that ranchers are still killing them."

Tonho da Onça—Jaguar Tony—one of the most famous jaguar hunters in Brazil, works with biologists tracking and anesthetizing jaguars so they can be radio collared for research. That he also still works as a hired gun for ranchers, nobody doubts. I told him I'd heard that ranchers are shooting nine or ten jaguars a month in the Pantanal. "Oh, no," he said in a vague, airy tone. "It's much more than that."

Bia doesn't blame ranchers who still resort to jaguar hunters. She hopes the reimbursement program will succeed, but she knows that not every fazenda owner can afford "to bankroll the jaguars." Nor is every fazenda right for ecotourism. For Bia, though, it's the way to keep ranching working for her, and for the Pantanal. "Though I will not," she says, "tolerate the tourists hugging my cowhands." □

**BRAKE FOR ANTEATERS** Increased traffic to the Pantanal means more wildlife ends up as roadkill. Read about the problem in Did You Know? Then find more Pantanal photos and resources ■ [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508).



# In Hot



**DEADLY LINEUP** Hurricanes slam into Florida and after another in this composite satellite image of storm tracks in August and September 2004—two of the most active months of Atlantic cyclones on record.

COMPOSITE IMAGE BY HAROLD F. PIERCE, NASA GODDARD SPACE FLIGHT CENTER  
NATIONAL GEOGRAPHIC MAPS



# Water



Last year was no fluke. The mighty Atlantic conveyor belt is in high gear, and sea-surface temperatures are up. That means we could be in for decades of coast-crushing hurricanes.

By Chris Carroll  
NATIONAL

Photographs by Tyrone Turner









**PULVERIZED** Ivan's ripping winds and surging seas demolished the upscale Grande Lagoon neighborhood near Pensacola, leaving possessions scattered and lives shredded. Many have yet to return to the neighborhood as they battle insurance companies in court for compensation.

**BEHIND THE SCENES** at this two days  
hit, go to, REM



One in five homes in Florida ~~was~~ damaged by hurricanes during August and September 2004. Tens of thousands of people were displaced.

## And it could have been worse.

**A**t midday the barrier island in Vero Beach has the weird feel of a place quickly and angrily abandoned. Poking around debris-lined streets among spray-painted signs all denigrating a certain Jeanne, I'm hoping not to be mistaken for a looter by a cop—or, worse yet, by an armed Floridian homeowner. Wind gusts drive intermittent sheets of rain as a few stragglers throw a last suitcase or heirloom into a car before scurrying over the causeway to the mainland. Jeanne, you see, is a major hurricane, already a killer of thousands in Haiti. This thin strip of land is surely not the place to be when she arrives in full force tonight.

The ghost town air of shuttered, boarded-up, duct-taped houses and condos prevails everywhere but the oceanfront, where visitors keep arriving. Police officers try to shoo them away. "We're under an evacuation order here, folks," they announce. "Don't even think about it!" a patrolman bellows at a pair of daredevils who drive up with surfboards strapped to their car. But as soon as the officers move off to another public beach, more hurricane pilgrims appear. Mostly they're locals who've come to curse at fate, or to ponder nature's cruel sense of humor, or maybe just to wearily accept what's coming.

Again.

Three weeks ago a cyclone named Frances tore into central Florida on a nearly identical path. That hurricane, the second to hit the state in the unlucky summer of 2004, left several feet of water in Greg McIntosh's house. Turning his back to a hard blast of wind, he wonders what Jeanne—storm number four—has in store.

"It's like in basic training when you get into your bivouac and then the sergeant blows the whistle and you have to go another ten miles in the dark," says McIntosh.

David Mitchell, a recent transplant to Florida,

leans on the railing above a seawall and stares over the rising sea. Monstrous swells crash into a breakwater a few hundred yards offshore.

"I've only been here four months, and in that time, two hurricanes," he says. He'll soon retreat to his apartment, where he has taped over the windows, even though that's not likely to offer much protection from windblown debris. "I guess when you live in Florida, it's just something you have to get used to."

Not just Floridians—anyone in the eastern coastal regions of the United States and Central America, as well as the entire Caribbean, is getting used to it. Since 1995 the Atlantic has been producing powerful hurricanes at a hyperactive pace, doubling that of the previous quarter century. If few in the U.S. noticed at first, it was because atmospheric conditions mostly kept the abundant storms out at sea or

**LIVES ERASED** Alex Norton, 19, sobs in the rubble of the Pensacola house where she grew up. "It was the only home she'd known," says her mother, Sandy Norton. Many buildings fell to Ivan's storm surge—a tsunami-like flood pushed ashore by hurricane winds.



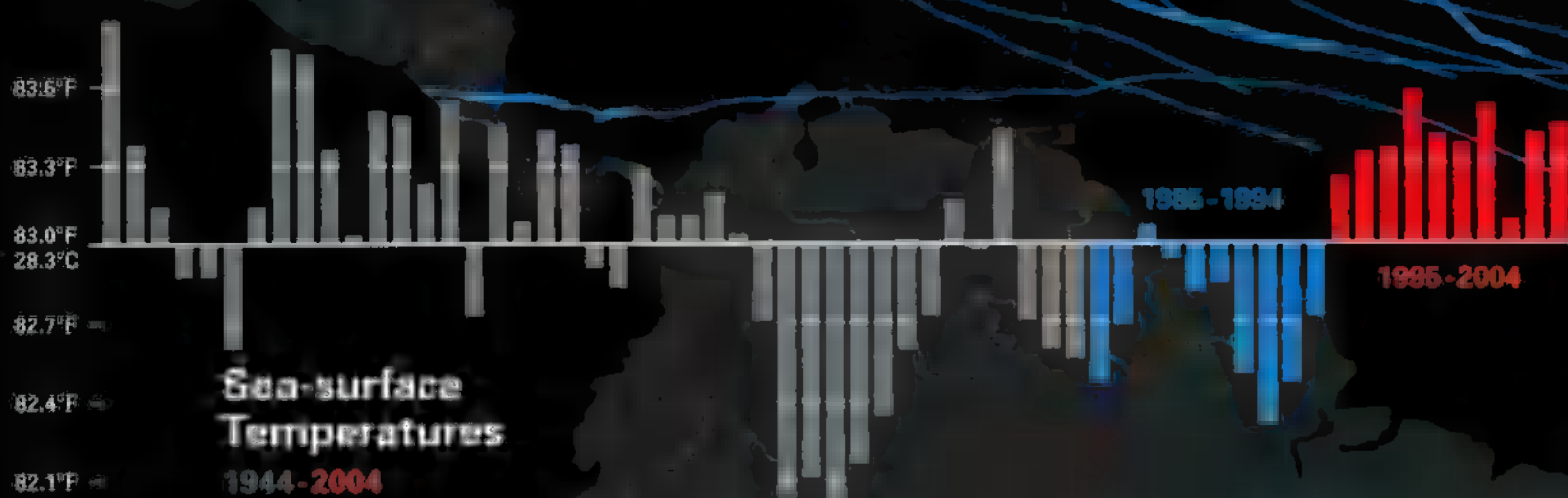




# Hurricane Tracks

When sea-surface temperatures were cooler (1985-1994)

Category 3-5  
Lower-intensity storm



headed elsewhere. But the winds shifted in 2004.

"The whole East Coast was very lucky for the past 30 or 40 years," says William Gray, of Colorado State University, a pioneer in long-range hurricane research and forecasting. Gray had predicted a damaging storm season for last year. "We'd been saying things would change, but nobody expected anything like the 2004 season."

The coming hurricane seasons might make last year's estimated 40 billion dollars' worth of U.S. damage look small. Warns Gray: "There's no way—if we see a return to the type of land-fall activity we saw in the thirties, forties, and fifties—no way but that economic losses will double, triple, quadruple, or worse."

That's because societal risk—roughly defined as the number of people and value of property vulnerable to hurricanes—has exploded. The southeastern coastal population has grown dramatically, with Florida's alone more than tripling since 1960. The economic risk has also multiplied. About 1.1 trillion dollars' worth of at-risk property was insured in 1980; the total now is an estimated 5.5 trillion dollars' worth. And the

latest census figures show that between 2000 and 2004, 29 of the 50 fastest-growing U.S. counties were in East Coast and Gulf Coast states.

The hurricane glut is happening at the same time sea levels continue to rise—the result of global warming that most scientists blame in part on human activity. A recent study using the latest computer climate models predicts warming of the tropical sea surface will strengthen hurricane winds and rainfall by the end of the 21st century. However, some experts, including Gray, argue that climate change due to human activity will not significantly affect hurricanes.

That debate will continue, but many scientists agree that the present hurricane surge is likely part of a 60-to-70-year cycle that changes the strength of ocean currents distributing heat around the globe. Researchers have used tree rings and ice cores to track this variability back hundreds of years. We're now in a fast-flowing mode of this up-and-down cycle, named the Atlantic Multidecadal Oscillation (AMO), during which Atlantic sea-surface temperatures and wind conditions favor hurricane generation. Ten





Now that they're warmer (1955-2004)

**RELATIVE CALM GIVES WAY TO FRENZY** Two ten-year periods of hurricane activity show that from 1955 to 1994, when sea-surface temperatures were low, there were half as many major hurricanes as during the most recent decade, when temperatures rose by one to two degrees F—the result of changes in ocean currents that cycle water and heat between the far northern Atlantic and the tropics. Frequency of major hurricanes rises and falls on a multidecadal time frame (graph at left) that scientists are still trying to understand.

years from now, or perhaps thirty (the timetable is difficult to predict), the cycle should reverse, tending to suppress major hurricanes.

Why the variation? “Frankly, no one can say with 100 percent certainty, but it appears to be a natural effect,” says Thomas Delworth, a climate modeler at NOAA’s Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey. Delworth is part of a major scientific effort to develop accurate computer climate models, and much of his work focuses on thermohaline circulation—that is, the way ocean currents, and consequently such cycles as the AMO, are driven by heat and salinity.

Thermohaline circulation runs the Atlantic conveyor belt, part of a global ocean system in which a continuous flow of upper-level water is drawn from the tropical Atlantic north toward the Pole. There the water cools, sinks, and cycles back to the southern oceans in deepwater currents.

As the conveyor belt speeds up, tropical surface water is drawn north more quickly, and temperatures in the North Atlantic are as much as 2°F warmer. That’s good for hurricanes.

“A hurricane is essentially an engine that runs on heat,” says Chris Landsea, a meteorologist at NOAA’s Hurricane Research Division in Miami. “The warmer the sea-surface temperature [it must be at least 80°F for a hurricane to start] and the more warm, moist air that’s available, the stronger a hurricane can become.”

How and where does the conveyor belt speed up, increasing the overturning circulation of warm and cold water? It’s at the point where cold surface water sinks that the acceleration of the Atlantic conveyor belt probably happens, Delworth says. Cold, dry air coming off Canada extracts heat from the water. When these winds blow stronger and colder than average over a number of years, increasingly chilled water sinks faster because it is more dense, intensifying the flow rate. Years of weaker and warmer winds have the opposite effect, slowing the conveyor belt.

Climate records indicate a correlation between a pattern of increased cold winds and the 1995 upswing in hurricane formation. “From the late sixties to the mid-nineties, westerly winds strengthened,” Delworth says. “The overturning





**SURGING INTENSITY** Sunshine illuminates the aftermath of Ivan in Orange Beach, Alabama. Forecasting when hurricanes will gain or lose strength is a challenge, but a new satellite imaging technology allows researchers to monitor rainfall inside storms to find “hot towers”—clouds that rise high above the ocean and release heat into the atmosphere, powering and intensifying the storm. Frances’s hot towers (red, opposite) rose more than ten miles at Category Three on August 30, 2004, as the storm passed northeast of the Leeward and Virgin Islands. A day later it reached Category Four, with sustained winds of 131 mph and higher.

circulation probably increased in that period in response.”

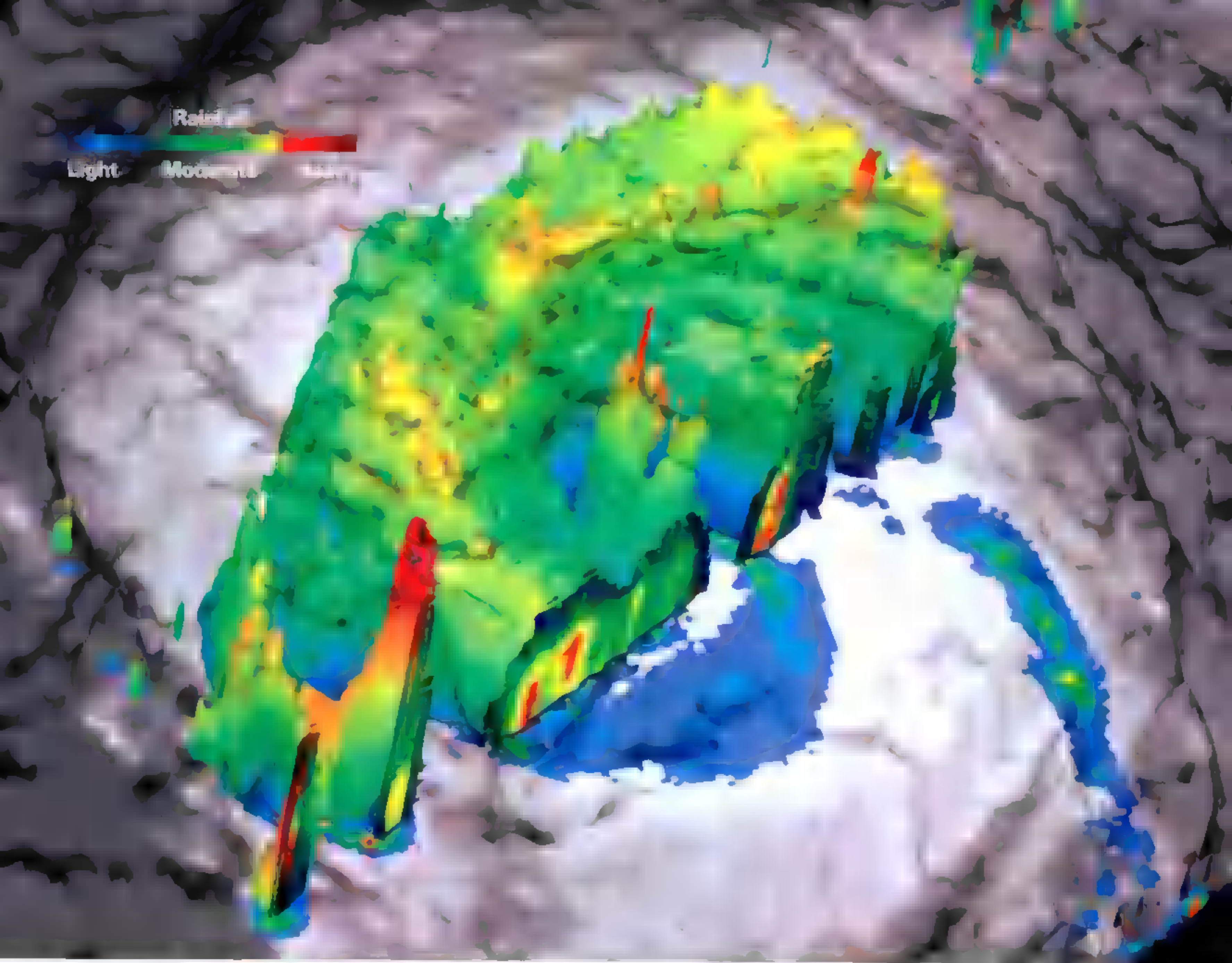
Increased circulation brings mighty storms—born as air spirals into a low-pressure zone charged with warm, humid air over warmer sea surfaces. The winds meet and ascend, causing clouds to billow upward, further lowering air pressure and causing winds to barrel even faster toward the center. The Earth’s rotation lends spin to the gathering cyclone. When water vapor in the ascending clouds cools and falls as rain, the amount of heat energy released dwarfs the amount of electricity consumed daily by all of humanity. The energy warms the eye, further lowering the pressure and strengthening the storm.

The cyclone can continue to strengthen if

atmospheric currents guide it over warm water, and if it is not destroyed by vertical wind shear—the differential between wind speeds at lower and higher altitudes. Strong wind shear can dissipate a storm, but the warm phase of the AMO tends to weaken vertical wind shear in the Atlantic.

The combined effect of changes in the AMO and the Atlantic conveyor belt has been dramatic. In the Caribbean, production of cyclones skyrocketed 400 percent. In the entire Atlantic Basin, major hurricanes, with sustained winds of 111 miles an hour or higher, increased 150 percent. The intensifying is most pronounced in powerful storms like Ivan, whose winds at times exceeded 155 miles an hour as it smashed past Jamaica and headed for landfall near Pensacola.





It was just after midnight on September 16, 2004. Residents of Grande Lagoon who chose to ignore evacuation warnings and ride Ivan out in their upscale homes flanking the Intracoastal Waterway west of Pensacola passed time reading, playing cards with their children, wondering if they had miscalculated.

The cacophony of wind and debris pelting their houses covered up any sound that might signal the approach of the real enemy—not wind, but a wide dome of seawater Ivan had piled up and was pushing toward them in the dark. This was the storm surge, the deadliest part of a hurricane for those living near water. Two men who survived the sudden flooding related this same sequence of events: They looked down first at a wet floor, then at a few inches of water around their feet. Each then opened the front door to a waist-deep onslaught of dirty seawater.

Three others who refused to evacuate the area died when the sea invaded their homes. The search for bodies delayed the return of residents who evacuated and then came back wanting to know what they had lost. For many, that turned

out to be everything they didn't take with them when they fled.

In the chaos of the aftermath, one couple in the neighborhood seems somewhat at home. Al and Dean Hoffman have set up camp in a tent trailer outside their devastated ranch house. At the moment, there's enough wood debris heaped against the house, which backs water, to rebuild several docks. A motorboat has pierced a side room. The interior is muck-coated and smells of rotting fish. But the retired couple will not be pushed from the coastline a second time.

"I came back to a concrete pad after Hugo hit South Carolina in 1989, so I can handle this," says Dean Hoffman. "We sure know how to pick 'em, don't we?" adds her husband, Al.

A big topic of conversation in hurricane-flooded communities is FEMA's "50 percent rule." If inspectors from the federal disaster agency determine that a house has sustained more than 50 percent damage, the structure must be rebuilt to the latest state and local codes. This rule protects the government-run National Flood Insurance Program—which pays up to \$250,000







**SHIFTING SANDS** Kyle Pruczinski makes the best of a bad situation on Pensacola Beach, battered by Hurricane Ivan. Work crews scraped up more than a million cubic yards of sand (about 34,000 dump-truck loads) that was washed away from beaches, screened out debris, and piled the sand into hills. The goal of the multimillion-dollar project is to restore beaches, but critics say coastal barrier islands like the one on which Pensacola Beach is built are not static landmasses, and should be allowed to erode and shift naturally. Home and business owners, naturally, disagree.

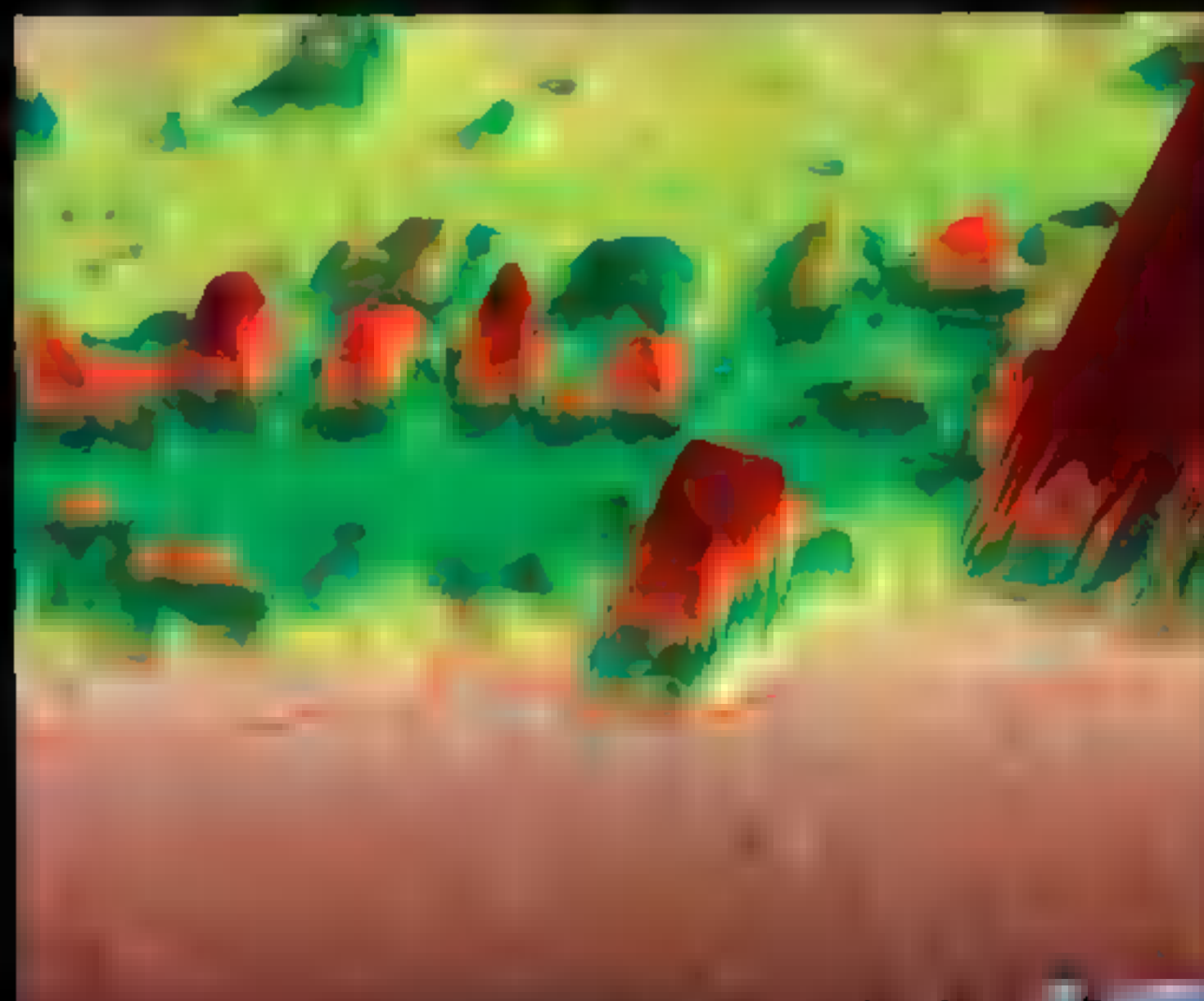
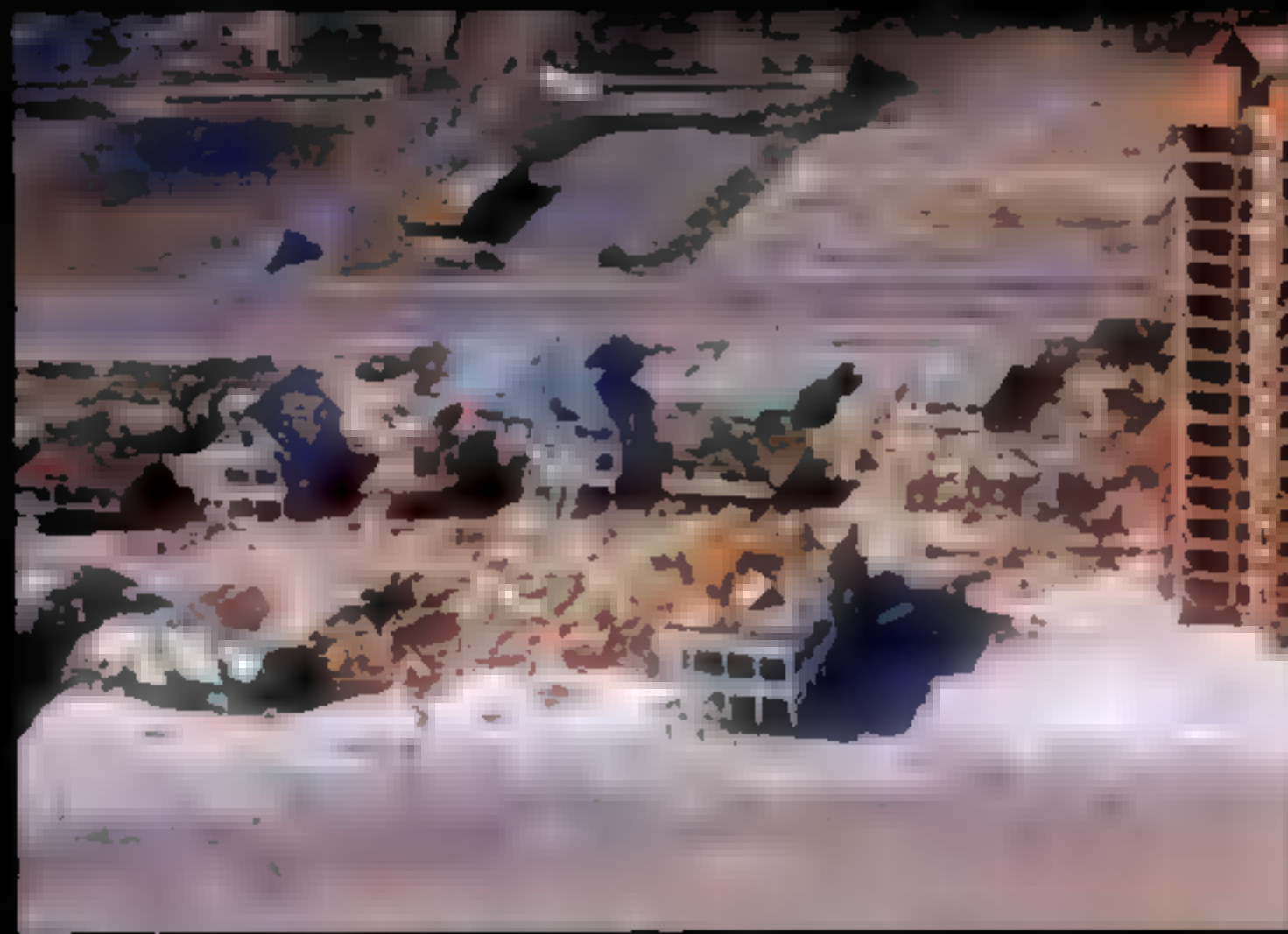




Pre-Ivan



Post-Ivan



**HERE TODAY, GONE TOMORROW** Beachfront houses in Orange Beach, Alabama, sit seemingly secure (upper left) behind the pre-Ivan edge of the primary dune, its base delineated as a red line on aerial topographic images (lower left and right). Ivan washed away some of the dune—and some of the houses (upper and lower right). Victims of Charley (opposite) sift through donated clothes in a federal emergency housing center. Tens of thousands of Floridians may still be living in such centers during this year's hurricane season.

for reconstruction—from repeatedly covering repairs to the same house. For Dean and Al the latest codes could require a new house on 10- or 15-foot pilings. “My God—can you imagine how ridiculous that would be?” Al asks, glancing up, perhaps imagining a ranch house among the trees. There’s no way his waterlogged home is more than half done for, he declares.

**A**ccording to the latest National Hurricane Center updates, which I’m monitoring the morning of September 25 in my Vero Beach hotel room, Jeanne has traversed luxuriously warm water and is now a major hurricane. As I study satellite images of the rotating cloud mass on the NOAA website, I’m perversely pleased that my

first hurricane won’t be of the garden variety.

I might be less sanguine were I not planning to ride out the storm in an absolute bunker of a house a few miles inland. I’ll be at the home of Jonathan Gorham, coastal engineer for Indian River County. His house was built in 2003 to all the latest hurricane codes. Gorham and his wife have also invited two other families to weather the hurricane with them. Their houses were seriously damaged by Frances and might not stand up to Jeanne’s pounding.

Our group, assembled and under assault by early evening, has been waiting for the calm of the storm’s eye. But sometime after midnight we realize there will be no letup—the eye is passing just south of us. “I’ve heard you can see the stars come out in the eye,” says Mike Bresette,





dejected, as he turns in for the night. I'm on a bedroll near the front door, which seems to bow inward with each hard gust. With the rumbling that's coming through the thick walls of the Gorham house, I begin to feel in my bones a measure of the fear many millions have known for as long as humans have lived near oceans.

So I'm deflated to learn some weeks later that for all its fury, the storm, where I was, was perhaps not all it was advertised to be. This news comes from Tim Reinhold, vice president of engineering at the Institute for Business and Home Safety, a research and education organization funded by the insurance industry. Reinhold, a former civil engineering professor, rode out each 2004 Florida hurricane while tending wind gauges and other instruments he set up at houses in the paths of the storms.

Jeanne's maximum sustained wind speed at landfall was 120 miles an hour. But slightly inland, the best Reinhold's instruments could offer was 87 miles an hour—a piddling Category One event. Charley, in August, remained genuinely powerful over land; the others lost significant force.

So what, exactly, is a major hurricane? "There's more than one kind of measurement, especially when we're trying to measure what people went through in the places they live," Reinhold says. But one thing is certain: Last season's devastation could easily pale in seasons to come before the current cycle reverses.

"When you looked at images of Jeanne, Frances, or Ivan, you didn't see a complete doughnut-shaped eye wall like you see in a really powerful hurricane," Reinhold says. "You see that in images of Andrew in '92. Andrew looked like a buzz saw." William Gray and his colleagues, who predicted last year's above-average probability of destruction, have done so again for this year. It may turn out the hurricanes of 2004 were but a wake-up call. The buzz saws might already be winding up far out at sea. □

**HURRICANE IN ACTION** Watch 2003's Isabel surge across the Atlantic toward North Carolina. Catch an online gallery of Tyrone Turner's photos and field notes from author Chris Carroll at [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508).









*A thick rain of volcanic ash sends a rat-size mammal (*Cobiconodon zonghoi*) and three dinosaurs (*Dilong paradoxus*) fleeing for their lives. Based on the features of a 125-million-year-old fossil preserved by such ashfalls, these cynodonts exhibit a downy covering of protofeathers, the first found among their family. The evolutionary precursors of true feathers, protofeathers were hairlike and probably developed for insulation.*

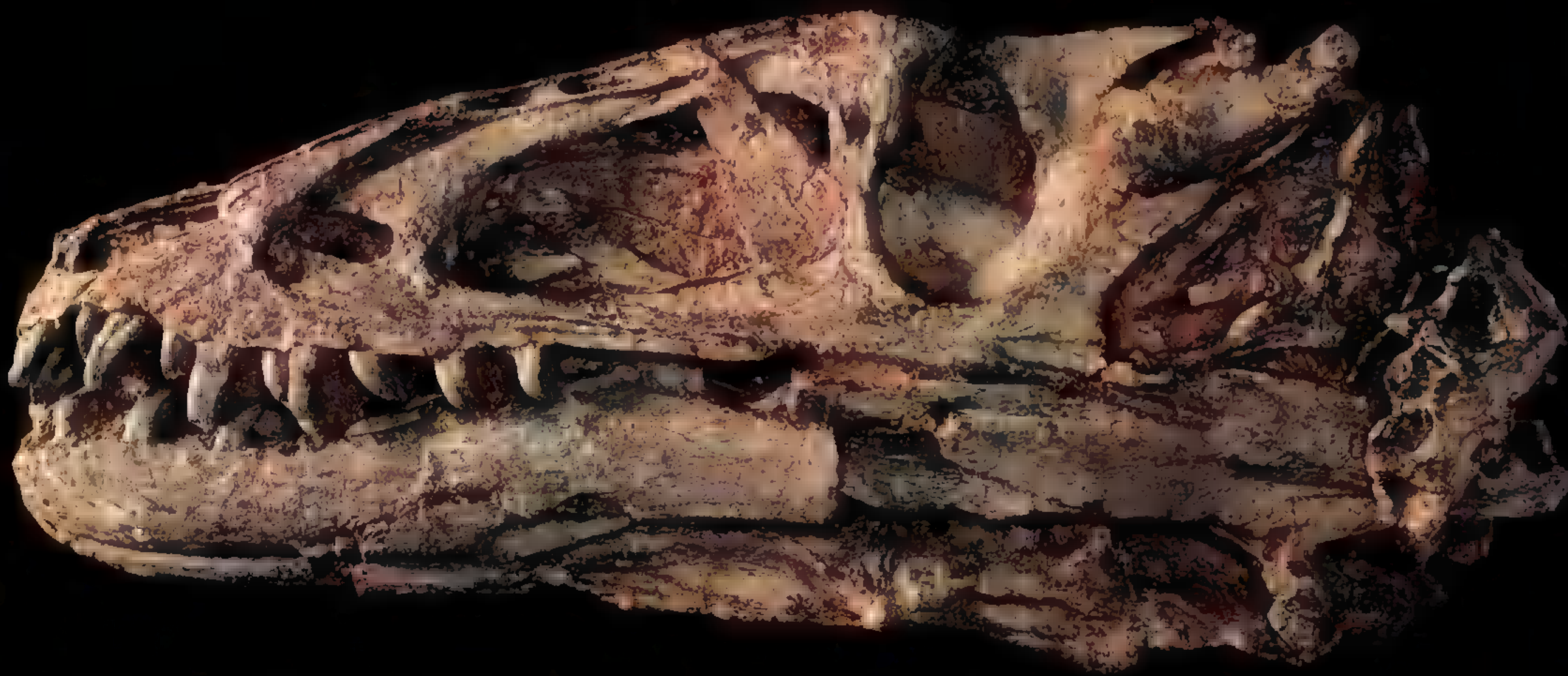


# Jewels in the ASH

China's Extraordinary Fossil Sites

By **LUKE TARPY** NATIONAL GEOGRAPHIC WRITER

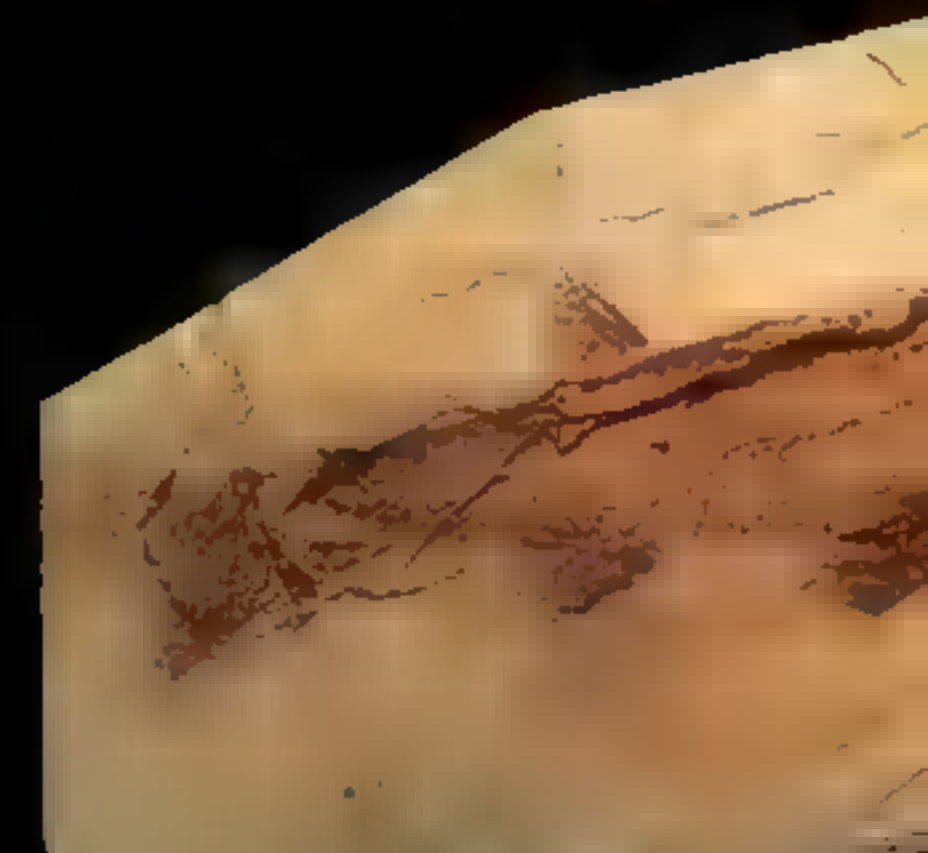
Illustration by **O. J. MATHIAS**



*Powerful teeth of Eotyrannosaurus resemble those of its more recent and much larger cousin. One of the oldest tyrannosaurs yet found, Eotyrannosaurus was unearthed in China's Liaoning Province. Preserved in clay, silt, and ash, a stunning array of dinosaurs, birds, mammals, and even insects makes the fossil beds among the most prolific in the world.*

...biplane, a dragonfly  
...lies grounded in  
...sediment...that  
...membranes...in star-

A bee's legs...  
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...tubular  
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PEIYAO STELEUS PANI



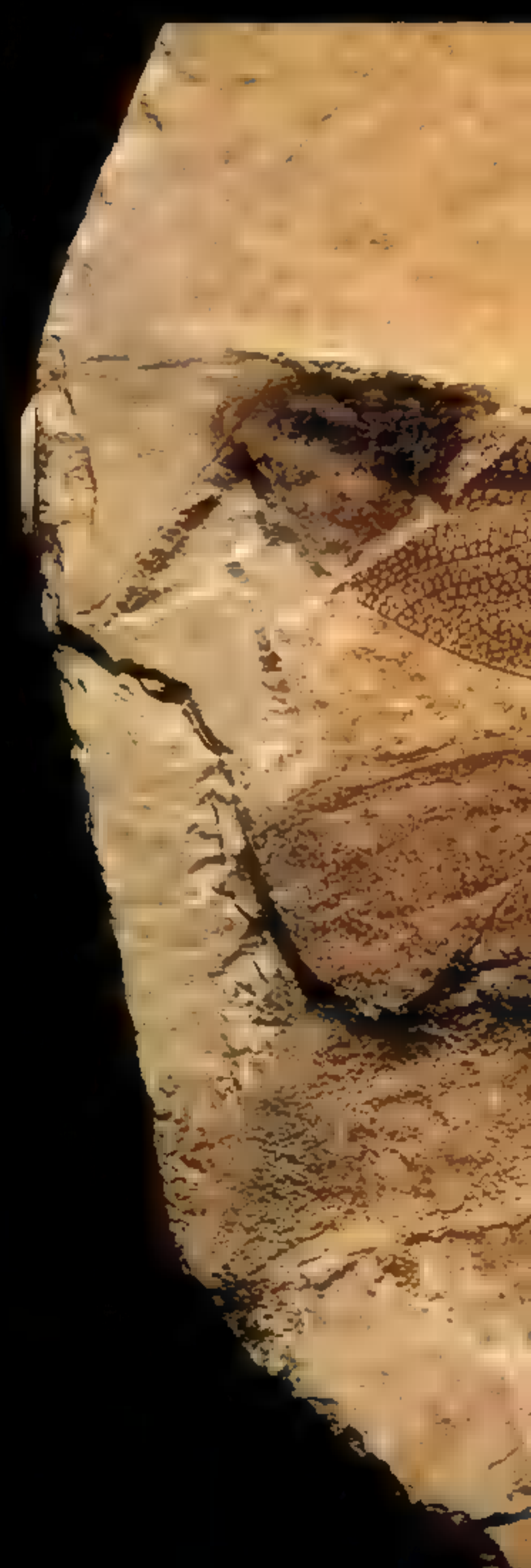
FLORINELESTUS PULCHERRIMUS

...played in the  
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A fish of  
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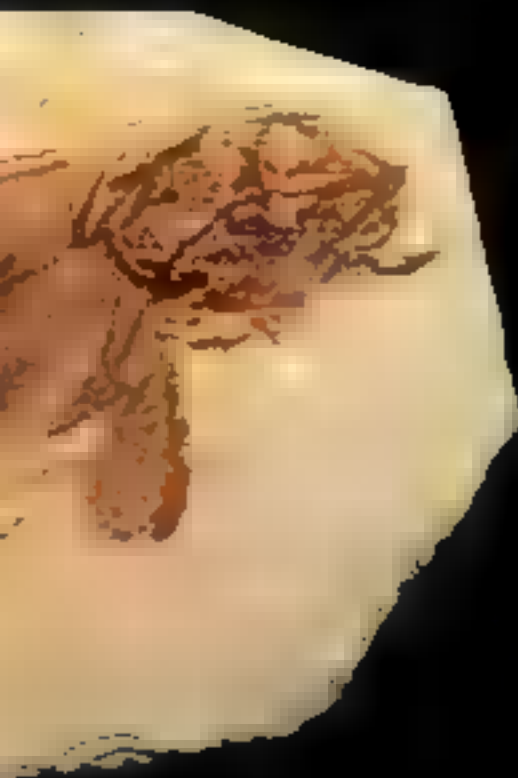
Protopteryx, a  
...bird (top center), sports  
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...head and...flight  
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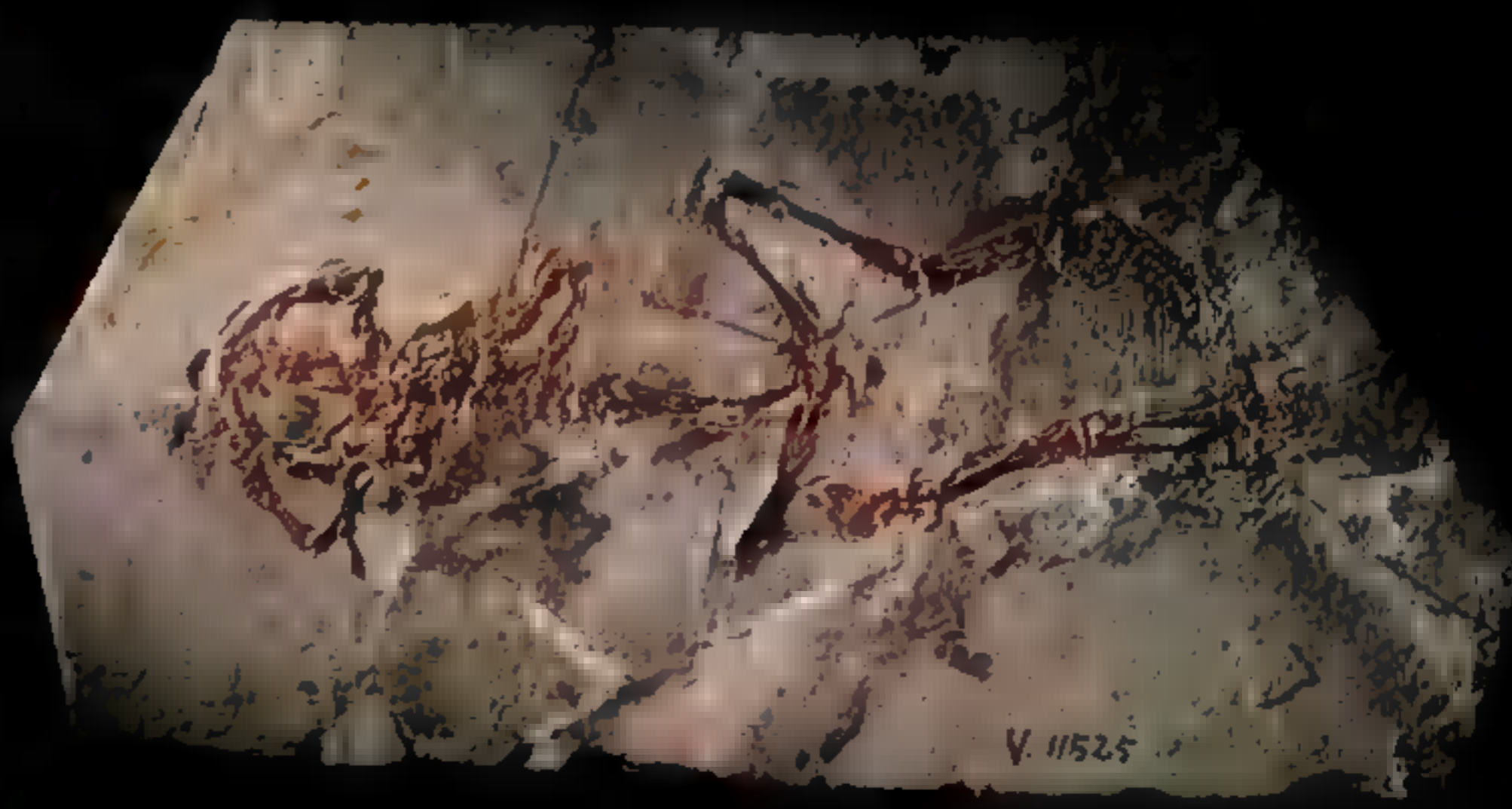


DIYONG PARADOXUS: ROBERT CLARK; FOSSILS, COURTESY INSTITUTE OF VERTEBRATE PALEONTOLOGY AND PALEOANTHROPOLOGY (IVPP), BEIJING, AND AMERICAN MUSEUM OF NATURAL HISTORY (AMNH), NEW YORK





*PROTOPTERYX FENGMINGENSIS*, IVPP



*CALLOBATRACHUS SANYANENSIS*, IVPP



*RUDIAESCHNA LIMNOBIA*, NATIONAL GEOLOGICAL MUSEUM, BEIJING (ABOVE, TOP LEFT, AND LEFT)





MARK LEDING (ABOVE); NATIONAL GEOLOGICAL MUSEUM, BEIJING (RIGHT)

**G**uarding long-buried treasure, a monitor at a dig site looks out for thieves who illegally remove fossils for sale to collectors. He sleeps in the one-room shack on the rim, keeping an ear cocked for voices in the dark.

In Liaoning Province, located in the rolling farm country of northeastern China, peasant farmers make only a few hundred dollars a year. They know they can make many times that amount by selling just one prized fossil on the black market. Even if recovered, illegally removed fossils have diminished scientific value, says Xu Xing of the Institute of Vertebrate Paleontology and Paleoanthropology

(IVPP) in Beijing: “If it isn’t collected right, a fossil loses its context—the layer it was found in and its relationship to other fossils.”

Xu, also a postdoctoral fellow at the American Museum of Natural History in New York, waxes enthusiastic about what has become one of Earth’s most celebrated fossil beds. Discoveries there are casting light on life during the Mesozoic, specifically 130 million to 110 million years ago—a time distinguished by the diversification of dinosaurs, mammals, birds, and flowering plants.

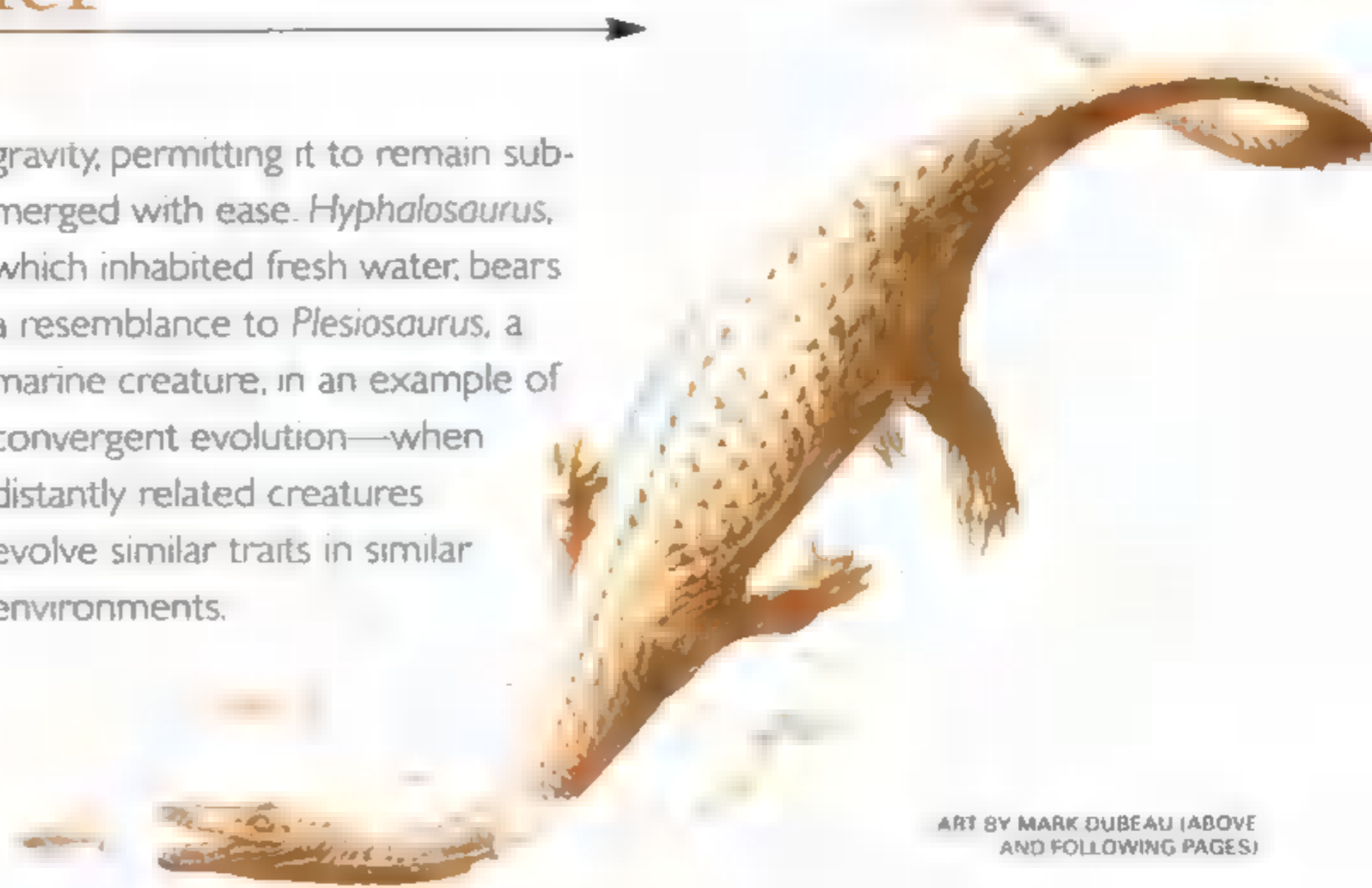
“Liaoning opens a window on the late Mesozoic that is more complete and more in-depth than anywhere else on Earth,” Xu asserts. The reason is the diversity and great

## Aquatic Prowler

*HYPHALOSAURUS LINGYUANENSIS*

A small fish lies next to the head of a fossilized specimen of *Hyphalosaurius lingyuanensis* (opposite), as if predation had been cut off by the sudden death of both predator and prey. That the animal, just under four feet long, was indeed a fish-eater is suggested by its small head, needlelike teeth, and pointed snout. The bulbous body apparently increased the creature’s specific

gravity, permitting it to remain submerged with ease. *Hyphalosaurius*, which inhabited fresh water, bears a resemblance to *Plesiosaurus*, a marine creature, in an example of convergent evolution—when distantly related creatures evolve similar traits in similar environments.



ART BY MARK DUBEAU (ABOVE AND FOLLOWING PAGES)







abundance of terrestrial plants and animals and their fossilization. At most sites only bone can be found. At Liaoning the fine particles of ash and mud that covered animals preserved soft body parts and prevented decomposition by sealing off oxygen.

Some scientists call Liaoning a Mesozoic Pompeii, evoking the ancient Roman city where humans were entombed by the eruption of Mount Vesuvius. But in its own way Liaoning is even more remarkable. Repeated volcanic eruptions created a layer cake of fossil beds spanning millions of years. So far, more than 60 species of plants, nearly 90 species of vertebrates, and about 300 species of invertebrates have been identified. Paleontologists marveled at dinosaur fossils with stomach contents identifiable as the bones of lizards and mammals, and at bird fossils containing plant seeds.

Liaoning is situated within a vast region whose primeval flora and fauna are referred to as the Jehol biota. The area was characterized by a warm climate and numerous lakes. These conditions provided a fruitful environment for plants and animals to differentiate and flourish. So many individual fossils have been found that scientists are able to study population dynamics, succession within

communities of interacting species, and even predator-prey relationships.

"The site preserved not just bones but often whole skeletons," says paleontologist Hans-Dieter Sues of the Smithsonian Institution, "and some birds were preserved so well you can distinguish between male and female. Liaoning is unique."

During the 1990s Liaoning jumped from the pages of scholarly journals onto front pages everywhere through a series of spectacular discoveries of archaic birds and—more intriguingly—dinosaurs with feathers.

These fossils bolstered the once controversial but now widely endorsed theory that modern-day birds descended from dinosaurs. They also provide much new evidence in the ongoing debate about how flight originated.

Fossils are being uncovered faster than paleontologists can describe the specimens and spread the new knowledge through scientific papers. And Liaoning promises to provide fresh discoveries for many years to come.



**DOWNLOAD DINO WALLPAPER** and send Mesozoic e-greetings of the dinosaur-eating mammal and other drawings from the article; then dig further into Liaoning, including On Assignment field notes from the photographer at [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508).

## Dino Becomes Dinner

REPENOMAMUS ROBUSTUS

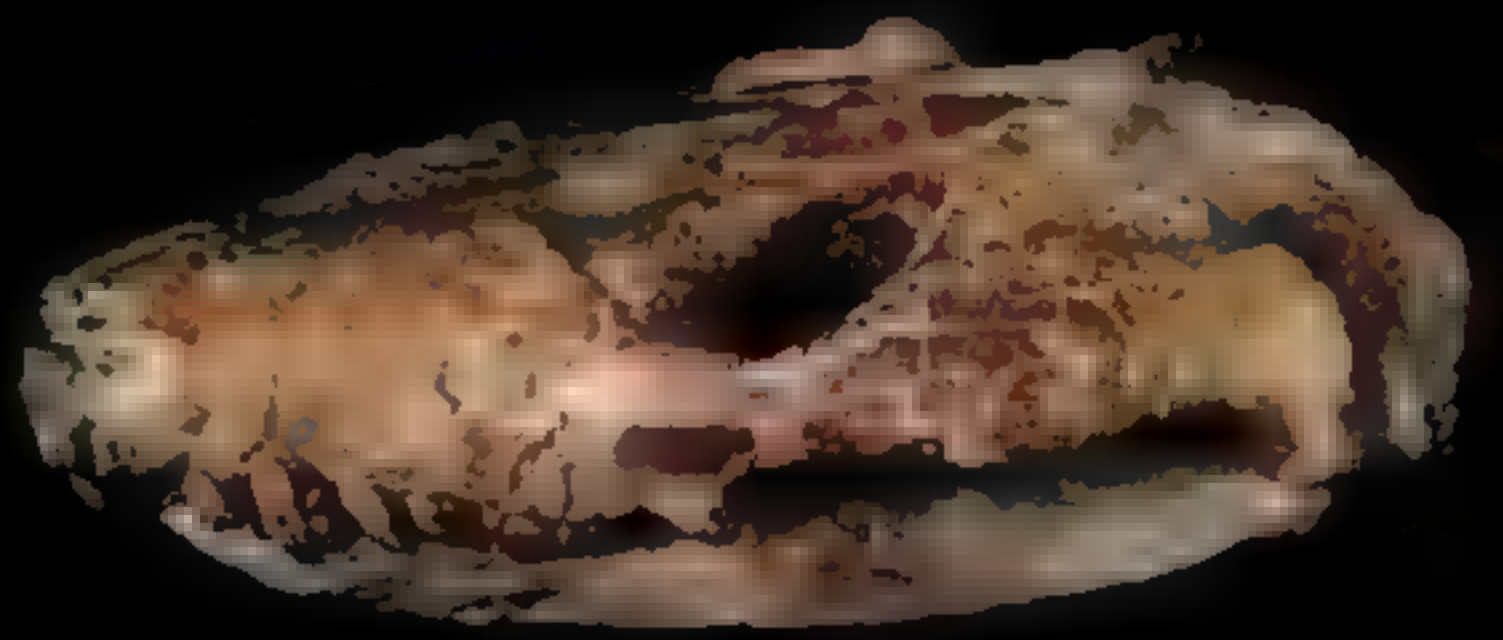
Scientists, who have long known that dinosaurs preyed on mammals, were stunned by the discovery of a fossil that turned the tables. Found by villagers, the cat-size mammal's skeleton contains the remains of its last meal: a young beaked dinosaur called *Psittacosaurus*. Most Mesozoic mammals were previously thought to be nocturnal insect-eaters no bigger than rats.

Uncertainties remain about the behavior of *Repenomamus robustus*, says Hu Yaoming of the IVPP. "Did

it catch the dinosaur after a pursuit? If so, that suggests it was diurnal—active in daytime when the dinosaur would also be active. But if it was a scavenger, it could have eaten it day or night." Whatever the case, *R. robustus* had allies: Liaoning also yielded a fossil of a cousin, *R. giganticus*, which was twice as big and presumably also had a taste for fresh meat.







## Last Meal

With large pointy teeth and powerful jaws designed for catching and ripping prey (above), *Repenomamus robustus* shows that Mesozoic mammals could compete with the smaller dinosaurs for territory—and food. Its stomach contents, shown in the inset below, included a hind limb of



the young beaked dinosaur, along with a forelimb and several teeth. These bones are well preserved and articulated—still joined to other bones in their natural positions—suggesting that *R. robustus*, rather than chewing, swallowed food in chunks.



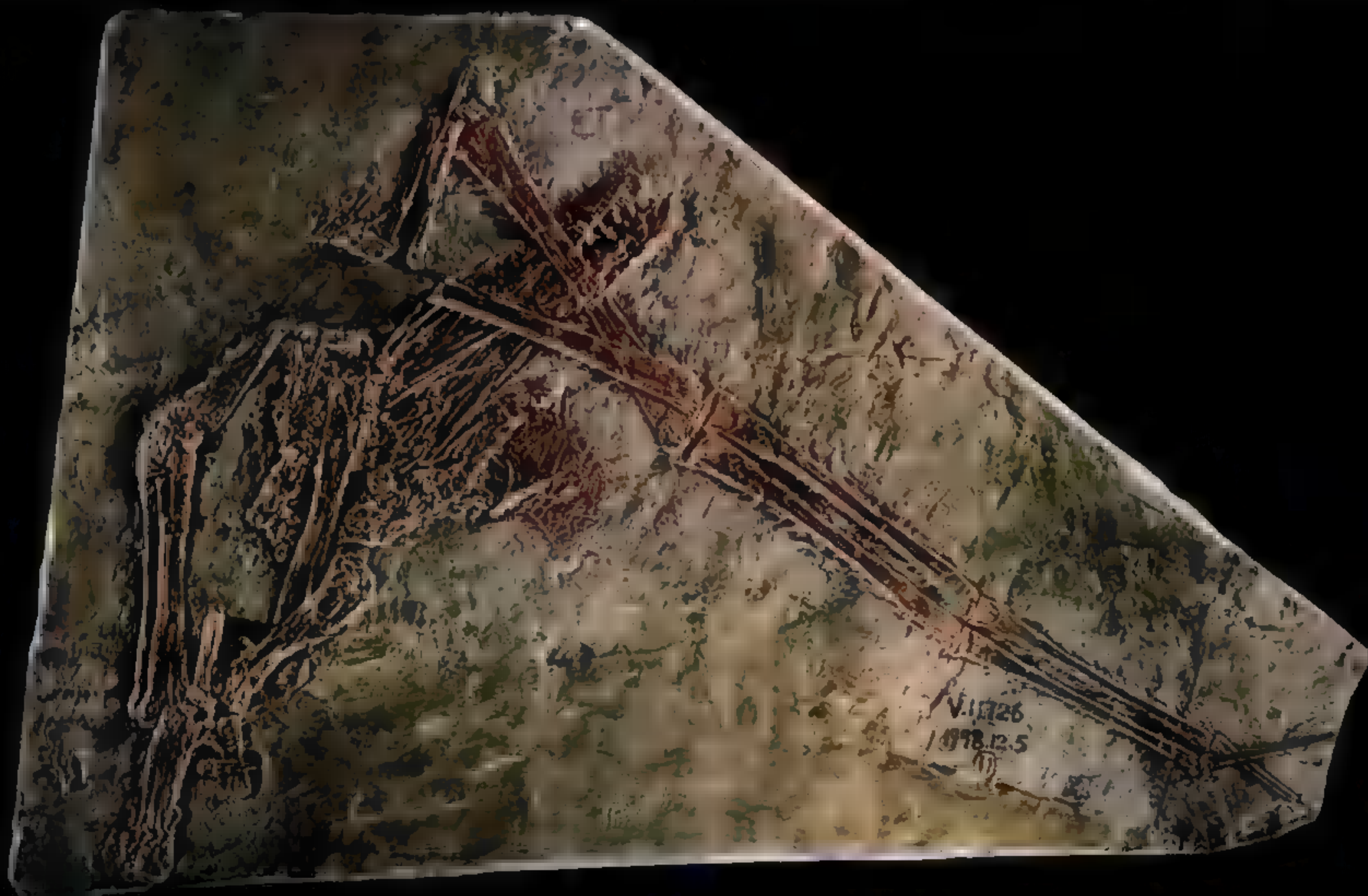
# Fish-Eating Flyer

*HAOPTERUS GRACILIS*

In death a pterosaur rests with a wing bone in its mouth (below), perhaps from the natural collapse of the wing, perhaps, as scientists speculate, from a struggle before volcanic gases snuffed out life. The pointed rostrum, or beak, and the sharp and slender front teeth suggest that it preyed on fish.

Long before birds and bats took wing, the skies were ruled by pterosaurs, reptiles that were Earth's first flying vertebrates. They lived 230 million years ago during the latter part of the Triassic period and thrived for 165 million years until going extinct at the end of the Cretaceous period.

The wingspan of *Haupterus gracilis* was nearly four and a half feet, easily exceeding the ten-inch span of *Pterodactylus elegans*, perhaps the smallest pterosaur, but falling far short of *Quetzalcoatlus northropi*, whose wings stretched at least 36 feet tip to tip. The pterosaurs' light, hollow bones aided takeoff. But their fragility also made fossilization difficult—best achievable in the soft ooze of the seafloor or lake beds like those at Liaoning. The discovery of *H. gracilis* and other pterosaurs at Liaoning, some preserved with body coverings of fuzz, extends the known range of pterosaurs.





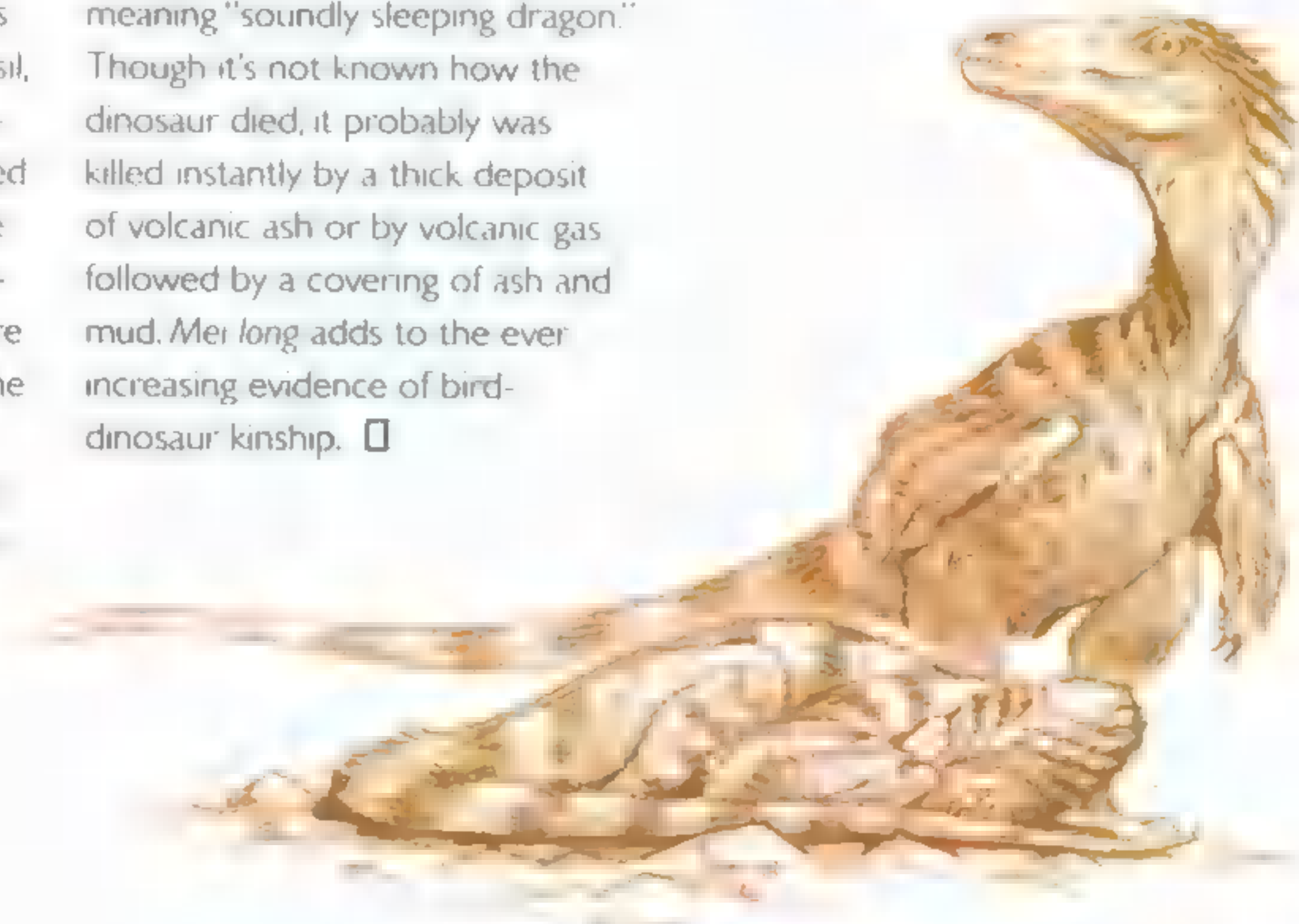


## Dinosaur's Swan Song

MEI LONG

In a rare instance of a vertebrate's behavior being revealed by its fossil, a new species of troodontid dinosaur was found with its head tucked under a forelimb. It represents the earliest known example of a dinosaur displaying the sleeping posture exhibited by modern-day birds. The "tuck-in" pose would have preserved body heat, suggesting that, like birds, at least some dinosaurs were warm-blooded. Delighted paleontologists named the pigeon-size creature *Mei long*.

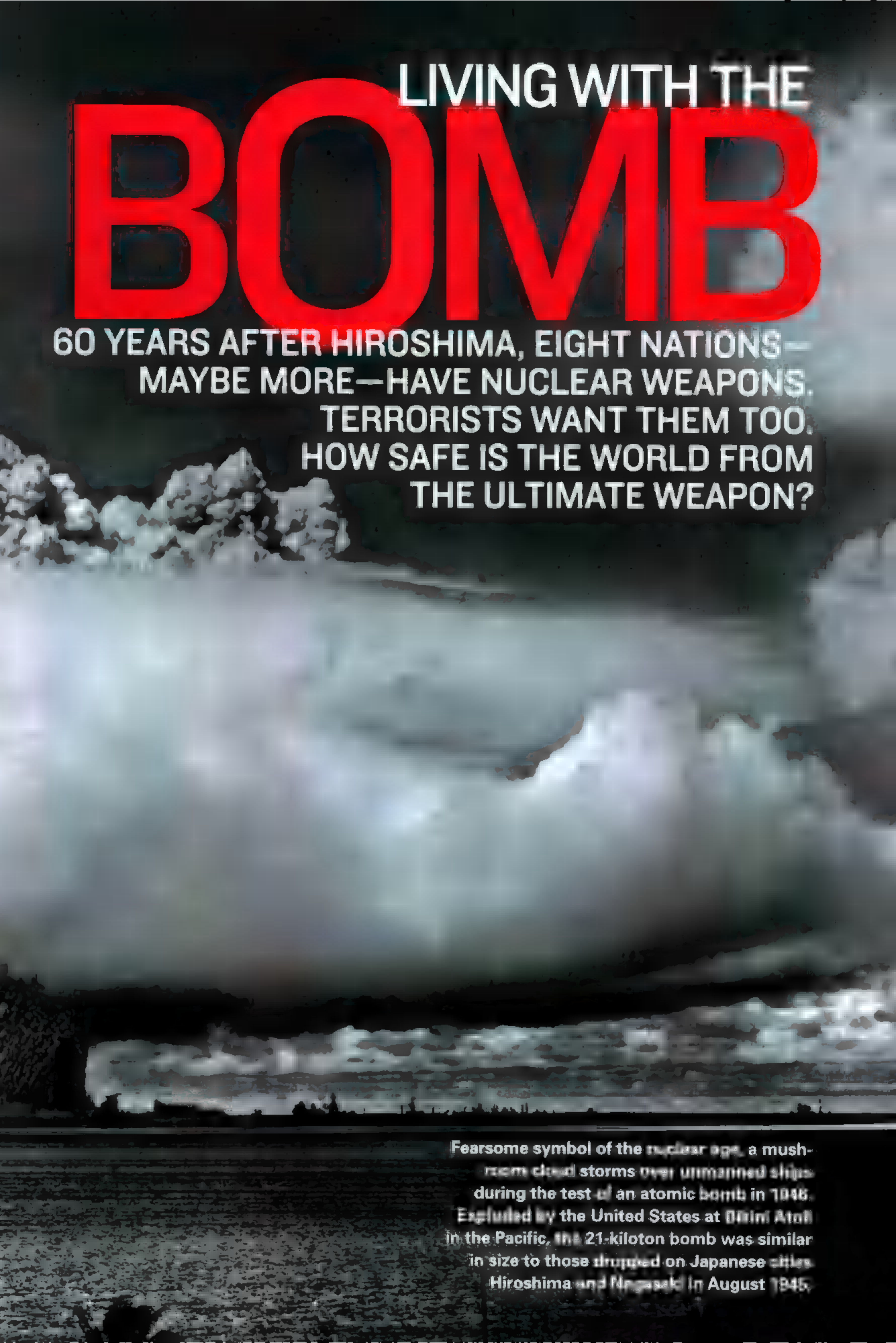
meaning "soundly sleeping dragon." Though it's not known how the dinosaur died, it probably was killed instantly by a thick deposit of volcanic ash or by volcanic gas followed by a covering of ash and mud. *Mei long* adds to the ever increasing evidence of bird-dinosaur kinship. □











# LIVING WITH THE **BOMB**

60 YEARS AFTER HIROSHIMA, EIGHT NATIONS—  
MAYBE MORE—HAVE NUCLEAR WEAPONS.  
TERRORISTS WANT THEM TOO.  
HOW SAFE IS THE WORLD FROM  
THE ULTIMATE WEAPON?

Fearsome symbol of the nuclear age, a mushroom cloud storms over unmanned ships during the test of an atomic bomb in 1946. Exploded by the United States at Bikini Atoll in the Pacific, the 21-kiloton bomb was similar in size to those dropped on Japanese cities Hiroshima and Nagasaki in August 1945.



BY RICHARD RHODES

# SIXTY YEARS AGO, ON A STORMY NIGHT IN 1945, THE CHARISMATIC AMERICAN PHYSICIST ROBERT OPPENHEIMER MOUNTED THE



**“We knew the world would not be the same.” So concluded physicist J. Robert Oppenheimer after witnessing the earth-shattering force of a nuclear weapon, first tested on July 16, 1945, in the New Mexico desert (right). North Korea now claims to be the ninth nation with a nuclear capability, after reprocessing plutonium from spent nuclear fuel rods (above) into weapons material.**

YONAP/AP/WIDE (RIGHT); (ABOVE): LOS ALAMOS NATIONAL LABORATORY

stage of a movie theater in the secret city of Los Alamos, New Mexico. Lean and intense, he was there to address hundreds of scientists—the men and women who built the first atomic bombs under his direction. Exploded over the Japanese cities of Hiroshima and Nagasaki on August 6 and 9, 1945, those bombs had just ended the most destructive war in human history—and changed the face of war forever.

The world would soon learn what they already knew, Oppenheimer warned: Nuclear weapons were surprisingly cheap and easy to make, once you understood how. Soon, he said, other countries would be making them, too. Their power of destruction—“already incomparably greater than that of any other weapon”—will grow, he declared. Despite these unsettling predictions, Oppenheimer found positive benefit in the breakthrough, calling nuclear weapons “not only a great peril, but a great hope.”

What was Oppenheimer thinking? The peril was obvious: Hiroshima and Nagasaki lay in ruins, with tens of thousands killed and thousands more seriously injured. What “great hope” nuclear weapons might offer was hard to imagine, even in victory. Sixty years later it still is.

Today eight countries brandish known nuclear arsenals, while approximately 20 others possess the technology and materials to go nuclear within a year or so if they choose. And nations are

**Richard Rhodes** is the author of 20 books, including *The Making of the Atomic Bomb*, which won the Pulitzer Prize, the National Book Award, and the National Book Critics Circle Award.







# THE RACE TO BUILD A BOMB (1938-1955)

AS HITLER'S ARMIES SWEEP through Europe and World War II anguishes the globe, the U.S. and Germany raced to become the first nation to create a nuclear weapon. A breakthrough came in 1942 when physicists in the U.S. split atoms in a controlled, self-sustaining nuclear chain reaction. Within three years the Manhattan Project, the secret American weapons program, applied the new science to make an atomic bomb, whose use in Japan ended the war—but also sparked a new arms race. By the late 1940s the U.S. and Soviet Union, competing for influence in postwar Europe and Asia, rushed to develop the even more powerful hydrogen bomb.



**1938 DECEMBER** Scientists Otto Hahn, Fritz Strassmann, and Lise Meitner discover nuclear fission. Bombarding an atom of radioactive uranium with neutrons

causes its nucleus to split, releasing a massive burst of energy.

**1939 AUGUST 2** Albert Einstein (left, at left), inspired on by fellow scientist Leo Szilard, at right, writes to President Franklin D. Roosevelt to warn that the U.S. must not fall behind Germany in atomic bomb research.

**1941 FEBRUARY** U.S. chemist Glenn Seaborg and his colleagues discover plutonium. Its fissile properties, like

highly enriched uranium's, make it a suitable explosive ingredient in nuclear weapons.

**1941 DECEMBER 7** Japan attacks U.S. military installations at Pearl Harbor, Hawaii, drawing America into World War II.

**1942 SUMMER** U.S. physicist Edward Teller advances the concept of a hydrogen fusion bomb, many times more powerful than an atomic bomb.

**1942 SEPTEMBER** Army Gen. Leslie Groves (below, at right) is named



only part of the story. The breakup of the Soviet Union put a vast array of nuclear weapons and materials at risk of theft or clandestine sale to non-state actors, either terrorist groups or criminal networks. Expertise too is in demand. The so-called father of the Pakistani bomb, Abdul Qadeer Khan, is reported to have passed nuclear secrets, weapons production technology, and bomb designs to Libya, North Korea, and Iran; some fear his network may have passed secrets to others as well. Since the mid-1990s Osama bin Laden and his followers have dreamed of acquiring nuclear devices to use in devastating attacks on the United States. No one knows whether terrorists are closing in on a radiological dirty bomb or even a nuclear weapon.

Oppenheimer's hope grew out of discussions with the brilliant Danish physicist Niels Bohr, who had escaped his Nazi-occupied homeland and found his way to Los Alamos late in 1943.

The spread of nuclear knowledge, Bohr told Oppenheimer, would eventually make nuclear weapons a common danger to all humankind, like a disease spreading to a global pandemic. When nations finally recognized the threat, Bohr and Oppenheimer agreed, the world would come together as never before—to limit the spread of nuclear weapons out of practical self-interest. And in forging those agreements through open negotiations and mutual understanding, nations would reduce the danger and ultimately banish war.

In the decades that followed, as one nation after another scrambled to acquire the bomb, the two scientists' vision of an open, safer world must have seemed naive. But despite this rush to arms, the dream of Bohr and Oppenheimer began to be realized in the 1960s, when, after a harrowing brush with nuclear war during the Cuban missile crisis, the U.S. and Soviet Union

## WHAT PROMISE DID OPPENHEIMER SEE IN THE GRIM



director of the Manhattan Project, the secret U.S. effort to build an atomic bomb. Groves recruits Robert Oppenheimer, at left, as scientific director.

**1942 DECEMBER 2**

A team led by Enrico Fermi achieves the first controlled, self-sustaining nuclear chain reaction at the University of Chicago.

**1944 DECEMBER**

As part of the Manhattan Project, large-scale plutonium production begins in Hanford, Washington, at a plant in Oak Ridge, Tennessee, uranium 235 is enriched.

**1945 JULY 16**

In a test code-named Trinity, the U.S. explodes the first atomic bomb at Alamogordo, New Mexico.

**1945 AUGUST 6**

B-29 bomber *Enola Gay* drops a 15-kiloton

atomic bomb, nicknamed Little Boy, on Hiroshima, Japan. Some 80,000 die immediately, followed by perhaps 20,000 more over the next few years.

**1945 AUGUST 9**

Fat Man, a 21-kiloton plutonium bomb, is dropped on Nagasaki, Japan, killing 39,000, with an estimated 35,000 additional fatalities. Japan surrenders days later.

**1946 JULY**

The U.S. begins atmospheric and underwater tests of weapons designs in the Marshall Islands.

**1949 AUGUST 29**

The Soviet Union becomes the world's second nuclear power when it explodes a copy of the Fat Man bomb in Kazakhstan. The bomb's design



was stolen from the U.S. by German-born scientist Klaus Fuchs.

**1950 JANUARY**

President Harry S. Truman authorizes accelerated research on a hydrogen bomb.

**1951 NOVEMBER 1**

Battlefield effects of blast and fallout are studied during Operation Buster-Jangle in Nevada, where soldiers are exposed to a 21-kiloton test six miles away (above).

**1952 AUGUST 3**

The United Kingdom tests an A-bomb in Australia.

**1952 OCTOBER 3**

The U.S. tests the world's first hydrogen bomb, code-named *Ivy Mike*, at Enewetak Atoll in the Marshall Islands.

**1955 AUGUST 22**

The Soviet Union successfully tests a hydrogen bomb, detonating a 1.6-megaton device in Kazakhstan.

TIME LIFE PICTURES/GETTY IMAGES (FAR LEFT); LOS ALAMOS NATIONAL LABORATORY (LEFT);

began to back away from the abyss. The world followed, and the result was the 1968 Nuclear Nonproliferation Treaty (NPT). In exchange for forgoing a nuclear arsenal, non-nuclear-weapons nations that sign the NPT (183 countries today, plus the five major nuclear powers) are promised that the major powers will work toward disarmament, won't transfer nuclear weapons to states that don't have them, and will share nuclear technology for civilian purposes. Subsequent test ban treaties further restricted the spread of nuclear weapons.

Despite their limitations, such agreements succeeded in reducing the threat from nuclear arms during the 1970s and '80s. They also confirmed that nations do not inevitably develop weapons when they acquire the means to do so. Going nuclear is a political decision, driven mainly by national security concerns, and those concerns often can be managed.

And then came 1991, when a geopolitical earthquake—the end of the Cold War and the fall of the Soviet Union—shook the architecture of agreements, loosening alliances and destabilizing the world anew. What had been one nuclear power, the U.S.S.R., fractured into a crowd of nuclear-armed countries. All battlefield nukes were returned to Russia in 1992, but three newly independent nations—Belarus, Ukraine, and Kazakhstan—retained thousands of warheads for intercontinental ballistic missiles (ICBMs).

Pressured by the U.S. and other countries, Belarus and Kazakhstan soon agreed to return their arsenals to Russia. “We had 81 mobile missiles, sufficient to eradicate Europe and the United States,” Stanislav Shushkevich, the first head of state of Belarus, told me. “But who were we defending from? So I thought that the sooner they were out of the country, the happier we would be.”

## WEAPONS HE AND HIS COLLEAGUES HAD DEVISED?



# WORLD OF WEAPONS [WHO HAS THE BOMB?]

THE GOOD NEWS is that the global arsenal of nuclear warheads has shrunk with the fall of the Soviet Union. The bad news is that nations continue to seek them. Pakistan went nuclear in 1998, and arms experts worry that North Korea already has the bomb and that Iran is working to build one. About 20 other nations possess the technology to build a nuclear weapon. And attempts to smuggle fissile material across borders (below) suggest that terrorists are also in the market.

## CLOSE

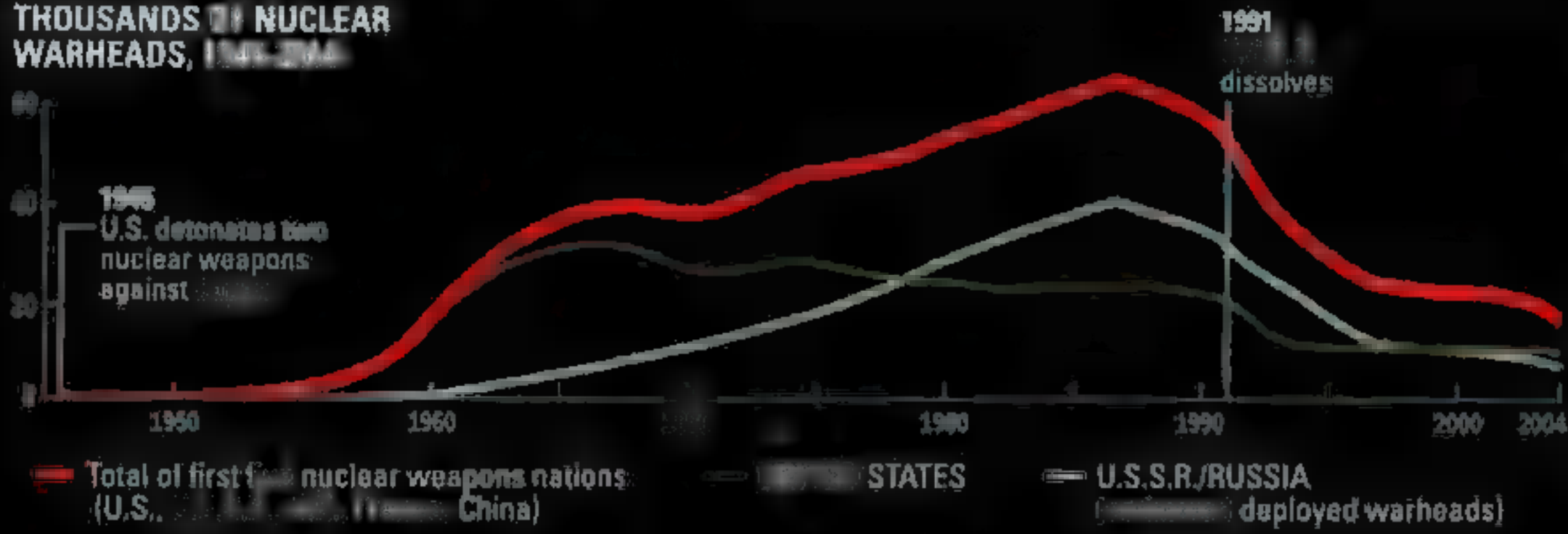
- 2001**
- ① **Asvestochóri, Greece**  
245 small metal plates of plutonium (Pu) found in a buried cache: 8.84 kilograms
- ② **Batumi, Georgia**  
People caught selling highly enriched uranium (HEU): 0.77 kilograms
- 1999**
- ③ **Ruse, Bulgaria**  
Customs agents arrest people trying to smuggle HEU at border: 0.01 kilograms
- 1998**
- ④ **Chelyabinsk region, Russia**  
Security agencies foil a conspiracy to steal HEU: 18.6 kilograms
- 1997**
- ⑤ **Sokhumi, Georgia**  
Russian inspection reveals HEU missing: 2 kilograms
- 1995**
- ⑥ **České Budějovice, Czech Republic**  
Police seize HEU: 0.016 kilograms
- ⑦ **Moscow, Russia**  
Men arrested with HEU stolen from nuclear facility: 1.7 kilograms
- 1994**
- ⑧ **Prague, Czech Republic**  
Police seize HEU: 2.7 kilograms
- ⑨ **Munich, Germany**  
Airport seizes HEU: 9.16 kilograms
- ⑩ **Tengen-Wiechs, Germany**  
Police detect Pu in building search: 8.85 kilograms
- ⑪ **St. Petersburg, Russia**  
Person arrested with HEU stolen from nuclear facility: 3 kilograms
- 1993**
- ⑫ **Vilnius, Lithuania**  
HEU discovered in storage area of a bank: 0.15 kilograms
- ⑬ **Andreyeva Bay, Russia**  
Thief steals HEU: 1.8 kilograms
- ⑭ **Murmansk, Russia**  
Russian naval officer steals HEU: 1.3 kilograms
- 1992**
- ⑮ **Podolsk, Russia**  
Worker steals HEU: 1.5 kilograms





# ARSENALS

THOUSANDS OF NUCLEAR WARHEADS, 1945-2004



ESTIMATED NUMBER OF WARHEADS, 2004

RUSSIA	16,000
U.S.	22,000
FRANCE	300
U.K.	225
CHINA	20-25
PAKISTAN	24-48
INDIA	100
NORTH KOREA	6-87

The last four countries on this list are not signatories to the Nuclear Non-Proliferation Treaty.





## ARMED FOR APOCALYPSE (1946–1987)

DURING THE DEEPEST FREEZE of the Cold War between the United States and Soviet Union, the superpowers embarked on an arms race that raised the specter of a doomsday war. Crises in Cuba and the Middle East threatened to trigger nuclear combat—and (if it came) annihilation. Nuclear weapons kept growing in number, power, and size, including the Mk-17 (below left), the heaviest bomb ever made by the U.S. Fears of all-out retaliation against a nuclear first strike kept the weapons sheathed and finally compelled the superpowers to sign the first arms-control treaties. “The ultimate instrument of war,” noted historian John Lewis Gaddis, “became . . . the ultimate inducement to peace.”



**1957 AUGUST**  
Soviets successfully test an intercontinental ballistic missile (ICBM).

**1957 SEPTEMBER 19**  
U.S. conducts its first underground nuclear test in the Nevada desert.

**1957 OCTOBER 4**  
The Soviet Union launches Sputnik, the first artificial orbiting satellite, igniting U.S. fears that the Soviets could attack from space.

**1957 NOVEMBER 8**  
The United Kingdom successfully tests a hydrogen bomb in the Line Islands of the Pacific.



Ukraine took a different view. It insisted on keeping its 1,240 strategic nuclear warheads to deter Russian aggression and to bargain for Western security guarantees and financial incentives. Under international pressure, Ukraine finally agreed to return the weapons to Russia in 1993 and sign the NPT. Today only Russia has nuclear weapons.

By most standards, the world is a safer place now than it was during the Cold War. As a result of various initiatives and arms control agreements, the U.S. and Russia have withdrawn thousands of “battlefield” nukes and long-range weapons from active deployment.

The U.S. nuclear arsenal today counts about 10,000 warheads, the Russian about 16,000—down from 32,000 and 45,000, respectively, during the Cold War. The Moscow treaty that Presidents George W. Bush and Vladimir Putin signed in May 2002 restricts the two countries

to no more than 2,200 deployed strategic warheads each by the end of 2012.

France and Britain have cut their arsenals; China is modernizing its weapons, but has tightened control on nuclear exports after reportedly providing Pakistan with the design information it needed to go nuclear. Israel’s formidable nuclear arsenal remains undeclared. Libya recently rolled up its program under pressure from Europe and the U.S.; Iraq’s more advanced program was dismantled by International Atomic Energy Agency (IAEA) inspectors in the years after the Persian Gulf war. India and Pakistan confirmed their status as nuclear powers with a series of underground weapons tests in May 1998, but neither nation has yet accumulated as many as a hundred nuclear weapons, and their recent nuclear saber rattling seems to have stimulated sober second thoughts.

That’s the good news.

**“INCREASINGLY,” SAM NUNN SAYS, “WE ARE BEING**



**1960 NOVEMBER 15**

The U.S.S. *George Washington* becomes the first submarine to carry nuclear ballistic missiles.

**1961 SEPTEMBER**

President John Kennedy urges Americans to look for fallout shelters (right).

**1961 OCTOBER 30**

The U.S.S.R. explodes the world's largest nuclear bomb, with a yield of roughly 50 megatons.

**1962 OCTOBER**

The U.S. Navy blockades Cuba after discovering that the U.S.S.R. is shipping nuclear missiles to the island. The Cuban missile crisis brings the U.S. and Soviets to the brink of nuclear war.

**1963 OCTOBER 7**

President Kennedy signs the Limited Test Ban Treaty (opposite) prohibiting nuclear testing in

the atmosphere, underwater, and in outer space.

**1964 JANUARY**

Premiere of *In. Strangelove*, a film satirizing the threat of accidental nuclear war between the U.S. and Soviet Union.

**1967 JUNE 17**

China successfully tests its own hydrogen bomb.

**1968 JULY 1**

The U.S., Soviet Union, and United Kingdom sign the Nuclear Non-Proliferation Treaty (NPT), followed by dozens of other nations. Today the treaty is signed by 188 countries.

**1966 AUGUST 24**

France tests an H-bomb in the South Pacific.

**1972 MAY 26**

President Richard Nixon and Soviet General Secretary Leonid



Brezhnev sign the Strategic Arms Limitation Treaty (SALT 1), the first agreement to limit the number and type of nuclear weapons systems.

**1973 OCTOBER**

The U.S. goes on nuclear alert during the Arab-Israeli Yom Kippur War. Israel reportedly develops nuclear weapons during the war.

**1974 MAY 18**

India detonates an underground nuclear device, called *Smiling Buddha*, in the Rajasthan desert.

**1983 MARCH 23**

President Ronald Reagan announces plans for the Strategic Defense Initiative, a space-based missile defense system against nuclear attack, later dubbed *Star Wars*.

RONALD REAGAN (FAR LEFT), ROBERT ROBERTSON, WHITE HOUSE/JFK LIBRARY (LEFT), BETTMANN/CORBIS

The bad news begins with two nations, North Korea, which may possess a small nuclear arsenal, and Iran, which is suspected of working to develop one. The U.S. considered going to war with North Korea in 1993 when the Koreans, already suspected of having one or two nuclear weapons, threatened to withdraw from the NPT and seemed ready to extract additional plutonium for weapons from spent reactor fuel.

Negotiations led to a compromise: North Korea shut down the reactor in question and allowed the fuel rods to be monitored by IAEA inspectors, in exchange for the promise of two nuclear power reactors, U.S. shipments of heavy oil for power generation, and better U.S.–North Korea relations.

The agreement held until 2002, when the Bush Administration accused North Korea of secretly working to produce highly enriched uranium (HEU) for weapons. The U.S. suspended

the vital oil shipments and moved to void the 1994 deal.


In retaliation North Korea expelled the IAEA inspectors, removed the fuel rods from storage, and said it would begin extracting plutonium. Enough had been bred in the rods to make four to six atomic bombs, and North Korea has since claimed to possess a small nuclear arsenal. Yet it surely knows that launching a nuclear attack on any of its neighbors, or the U.S., would invite a devastating response.

“We are not in a position to blackmail the U.S.—the only superpower,” a North Korean official told a U.S. congressional delegation visiting Pyongyang in June 2003. “Our purpose in having a deterrent is related to the war in Iraq. This is also related to statements by the hawks within the U.S. administration. If we don’t have a nuclear deterrent, we cannot defend ourselves.”

Iran is an even more complicated case. For

**WARNED THAT NUCLEAR TERRORISM IS INEVITABLE.”**



A large, billowing white cloud from a hydrogen bomb test against a clear blue sky. The cloud is on the right side of the frame, rising from the bottom right towards the top right. The rest of the sky is a uniform, clear blue.

The terrible beauty of a hydrogen bomb blast fills the sky at a 1962 U.S. test site in the Pacific Ocean. Despite decades of international agreements and the end of a Cold War nuclear standoff, the world is still imperiled—in new and unpredictable ways—by the most powerful weapon man has yet devised.







# GROUND ZERO [SCENARIOS FOR A NUCLEAR ATTACK]

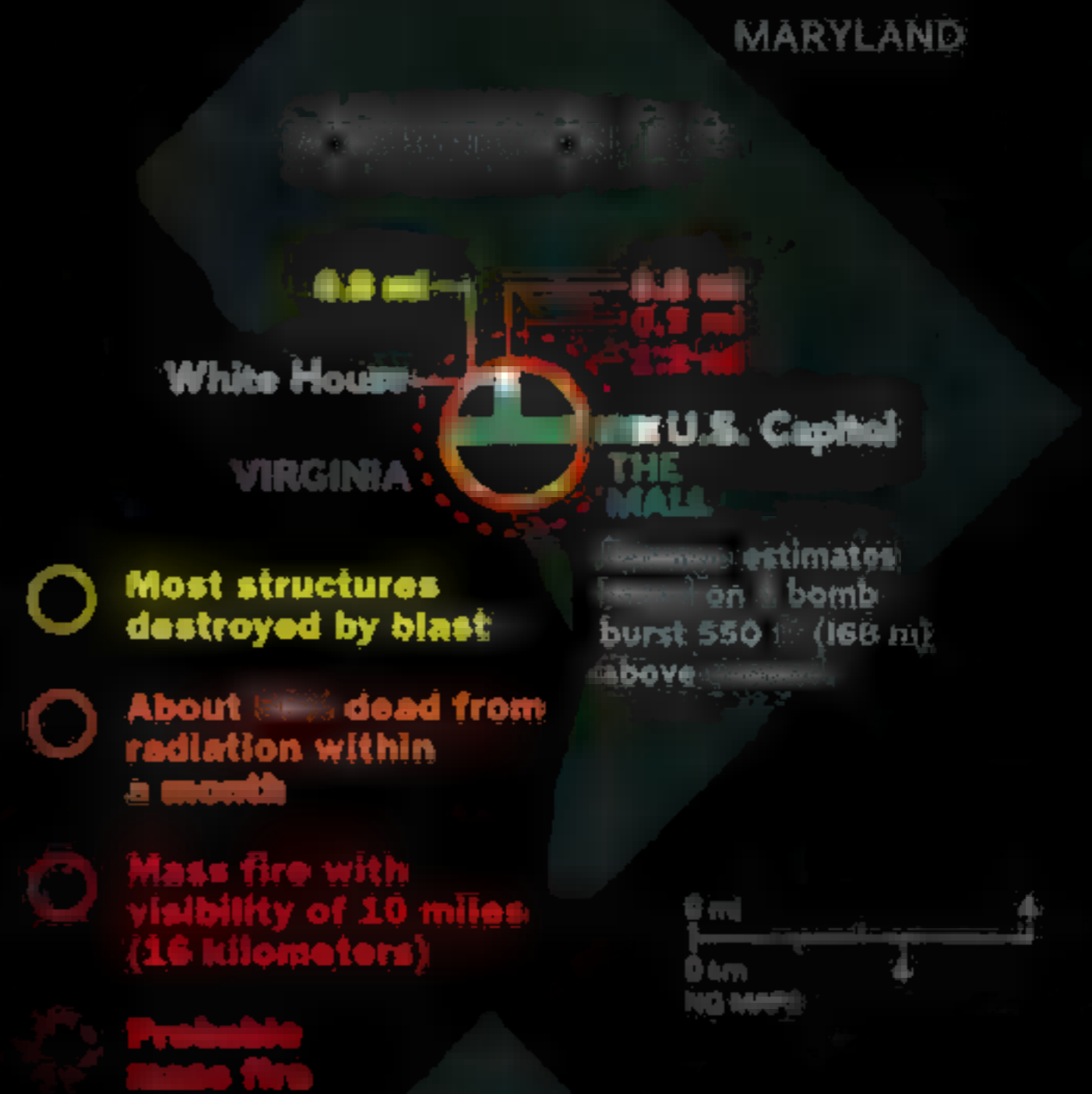
WHAT IF A NUCLEAR WEAPON WAS USED TO ATTACK WASHINGTON, D.C.? That explosion—from an atomic, hydrogen, or suitcase bomb—would hurl a lethal curtain of blast, fire, and radiation over the nation's capital. Besides crippling the U.S. government, it would alter life in the city for years.

## ATOMIC BOMB [1945] 15 KILOTONS

**THREAT** Used in 1945 against Japan, such bombs are now held by eight states, within reach of 20 more, and are sought by terrorists and criminals.

**TECHNOLOGY** The mechanism works by forcing two "subcritical" masses of  $^{235}\text{U}$  together, or compressing a spherical mass of HEU or plutonium to start an uncontrolled fission reaction.

**DAMAGE** A Hiroshima-size bomb would level downtown D.C., killing tens of thousands of people.



## HYDROGEN BOMB [1952] 300 KILOTONS

**THREAT** First tested by the U.S. in 1952 and the Soviet Union a year later, such weapons are held by the majority of today's nuclear powers.

**TECHNOLOGY** Heating and compressing hydrogen isotopes with the heat from a small atomic bomb triggers a powerful fusion reaction.

**DAMAGE** All living things within several miles of ground zero would likely be engulfed in a firestorm. Total dead: hundreds of thousands.



## SUITCASE BOMB [PRESENT] 10 KILOTONS

**THREAT** Capable of being precisely targeted and delivered by truck, boat, or suitcase, these weapons are easily concealed, and thus the most dangerous.

**TECHNOLOGY** Triggered by miniaturized electronics, a 35-pound nuclear device would deliver the explosive power of 10 tons of TNT.

**DAMAGE** Blast and radiation would flatten buildings and kill people within a few hundred yards, and be worth millions of dollars' worth of damage.





decades it has worked secretly to build the capacity to enrich uranium using centrifuges, in violation of its IAEA obligation to disclose all nuclear activities. When exposed, it claimed it was developing a complete nuclear fuel cycle to support a planned nuclear power program. Since centrifuges can produce HEU for weapons as well as low enriched uranium (LEU) for power reactors, and Iran kept its efforts secret, the IAEA is suspicious.

Further, a factory operating 50,000 centrifuges, which Iran plans to build, could produce enough HEU for up to 25 bombs a year. Significantly, Pakistan also enriched uranium (rather than breeding plutonium in a reactor, which is harder to conceal) as its initial route to the bomb.

If Iran continues to develop its industry, even short of making bombs, it may become a "virtual" nuclear power, capable of fielding nuclear weapons within a year of starting a dedicated effort. And because Iran's theocracy is openly hostile toward Israel, such a capability may be militarily unacceptable to Israel and its ally the U.S.

The most frightening prospect, however, involves not nations but terrorists—and the theft or sale of weapons-grade material from the countries of the former Soviet Union, or from rogue states like North Korea.

During the Cold War, the U.S.S.R. used a system of "guns, guards, and gulags" to protect its external borders and ensure domestic security, so that the nuclear materials dispersed throughout its far-flung network of weapons complexes and research centers were inherently secure, if not particularly well guarded or documented. When the U.S.S.R. dissolved and its zealously guarded perimeter opened, the Russian government faced (and failed at first to appreciate) a host of new challenges—ranging from an army of suddenly unemployed nuclear scientists to the monumental task of keeping up with its nuclear material and preventing it from being stolen and smuggled to outside groups or states.

The U.S., with its more porous borders, had long ago learned to track and account for nuclear materials and offered its expertise to Russia. While scientists on both sides urged cooperation, mistrust lingering from the Cold War delayed agreement between the two countries well into the 1990s, and even then the joint effort

was underfunded and hobbled by suspicion.

Since 1991 the U.S.'s Nunn-Lugar Cooperative Threat Reduction program has supported efforts to secure and eliminate these weapons and materials, but former Senator Sam Nunn, co-sponsor of the legislation with Senator Richard Lugar, estimated at the beginning of this year that the job of securing Russia's nuclear materials was only "between 25 and 50 percent" complete.

"Increasingly," Nunn says, "we are being warned that an act of nuclear terrorism is inevitable. I am not willing to concede that point. But I do believe that unless we greatly elevate our effort [to secure nuclear materials] and the speed of our response, we could face disaster."

The Soviets did not keep good records, so how much nuclear material is still out there, unaccounted for, is not known. Small quantities are known to have been bought and sold illegally (map, pages 104-105), but as far as we know, no non-state actor has managed to acquire the minimum mass of material—about four kilograms (nine pounds) of plutonium or 15 kilograms (33 pounds) of HEU—necessary to make a first-generation atomic bomb.

Of the various scenarios for an act of nuclear terrorism, the most plausible is a "dirty" bomb, a conventional explosive packed with radioactive material from medical or industrial sources. Experts describe dirty bombs as "weapons of mass disruption" because of the panic and contamination they would cause. Cleaning up after an attack on a major city could take months and cost tens of billions of dollars, while the most serious casualties of such a bomb would be those who were injured or killed by the initial blast.

Far more devastating would be a terrorist bomb fueled with stolen HEU or plutonium and delivered by some low-tech means like a boat or a truck. The near impossibility of detecting such an attack in advance is what keeps the world's civil defense officials awake at night and what has led U.S. policymakers to embrace preventive war as their best defense against a terrorist strike.

Surprise attack has been the recurring nightmare of the nuclear age. To preempt a Soviet surprise attack, the U.S. National Security Council considered a first strike against Moscow in 1954, as some U.S. experts judged America's arsenal



## BACK FROM THE BRINK [1985–2005]

ECONOMICALLY DEPLETED after decades of keeping pace in an expensive arms race, the Soviet Union finally collapsed in 1991, ending the Cold War. The result: The U.S. and Russia have since dismantled approximately 25,000 nuclear weapons, destroyed hundreds of missile systems, and are working to safeguard Russia's remaining bomb material. Yet the danger remains. The U.S. and Russia retain thousands of warheads, and neighbors India and Pakistan feud over Kashmir, North Korea's nuclear capability and intentions remain a question mark, and terrorists follow the nuclear materials black market. As long as these weapons exist, experts warn, their specter will haunt the world.



**1985 MARCH**  
Mikhail Gorbachev, a 54-year-old reformer, ascends to the leadership of the Soviet Union.

**1985 NOVEMBER**  
At their first summit conference in Geneva, U.S. President Reagan and Soviet leader Gorbachev signal a new era of arms control, agreeing that a nuclear war "cannot be won and must never be fought."

**1986 DECEMBER**  
U.S. deploys Peacekeeper ICBMs, each with ten nuclear warheads (right) to counter Soviet SS-18s.

**1987 DECEMBER 8**  
President Reagan and

Soviet leader Gorbachev sign the Intermediate-Range Nuclear Forces Treaty, the first pact to eliminate a class of nuclear weapons.

**1989 SEPTEMBER**  
South Africa resolves to dismantle its six nuclear bombs.

**1991 JULY 31**  
President George H. W. Bush and Soviet leader Gorbachev sign the Strategic Arms Reduction Treaty (START 1), calling for the removal



sufficiently superior to the Soviets' to justify taking such a risk; President Dwight D. Eisenhower rejected the plan. In the 1960s, any thoughts of preemption were replaced by faith in the power of deterrence—"mutual assured destruction"—as the U.S. strategy to counter a Soviet attack.

President Ronald Reagan believed that "Star Wars" technology could shield his country from nuclear attack, and in 2004 the U.S. actually installed, in Alaska, a limited successor to Reagan's Strategic Defense Initiative missile-defense system. But no such system yet operates to intercept clandestine weapons delivered by aircraft, ships, or trucks. After 60 years of searching for a fail-safe defense against nuclear attack, none has been found, nor is one likely to be found against weapons that even in their crudest forms can be made relatively small and portable, and vastly destructive.

Sam Nunn has called for nuclear nations to

"visibly and steadily reduce their reliance" on such weapons, to make them "less relevant" and thus less desirable. The signatories of the Nuclear Nonproliferation Treaty are currently considering a treaty to ban the production of plutonium or HEU for weapons, with existing stockpiles diluted and recycled as fuel in nuclear reactors. Such a program is already operating between the U.S. and Russia through a U.S. company, USEC, Inc., which to date has purchased 250 tons of diluted bomb-grade material from Russia—equal to about 10,000 nuclear warheads—for resale to U.S. nuclear power companies, which process it to make electricity. The lights of Boston, for example, are powered in part by Russia's recycled nuclear weapons.

Such initiatives are steps in the right direction, Nunn said recently, but they don't address the greatest threats we face today—"catastrophic terrorism, a rise in the number of nuclear

## AFTER 60 YEARS OF SEARCHING FOR A . . . DEFENSE



of about half the strategic nuclear warheads.

**1991 DECEMBER 25**  
Soviet Union dissolves.

**1992 MAY 23**  
Belarus, Kazakhstan, and Ukraine—countries formed after the fall of the Soviet Union—agree to dismantle their nuclear weapons (far left) and return them to Russia.

**1992 SEPTEMBER 23**  
The U.S. conducts its last underground nuclear test.

**1995 MAY 11**  
To control the spread of nuclear weapons, signatories agree to extend the Nuclear Non-Proliferation Treaty (NPT) indefinitely.

**1996 SEPTEMBER 19**  
The United Nations adopts the Comprehensive Test Ban Treaty, sending it to member states to sign.

**1998 MAY 11, 13**  
India conducts underground nuclear tests; its citizens celebrate in the streets (right).

**1998 MAY 28, 30**  
Pakistan conducts nuclear tests in response to India's.

**1999 OCTOBER 13**  
The U.S. Senate fails to ratify the Comprehensive Test Ban Treaty.

**2002 MAY 24**  
U.S. and Russia sign the Strategic Offensive Reductions Treaty. Each nation agrees to cut its deployed strategic arsenal to 2,200 warheads by the end of 2012.

**2002 AUGUST**  
Iranian dissidents report that Iran is secretly building two nuclear reactors. Subsequent International Atomic Energy Agency inspections reveal a



decades-long secret program to develop uranium enrichment technology.

**2002 DECEMBER**  
North Korea expels IAEA inspectors, curtailing the world's capacity to monitor its nuclear program.

**2003 JANUARY 10**  
North Korea announces its withdrawal from the NPT.

**2004 FEBRUARY**  
Pakistan acknowledges the head of its

nuclear program, Abdul Qader Khan, passed nuclear secrets to other countries, said to include North Korea, Libya, and Iran. The government places Khan under house arrest but blocks the IAEA or other foreign investigators from interrogating him.

**2005 FEBRUARY 16**  
North Korea announces that it possesses nuclear weapons, although its claim can't be verified by the IAEA or other outside experts.

AP/WIDE WORLD PHOTOS (FAR LEFT); PAUL SHAMBRUM (NUKEPHOTO); LEFT); KAPOOR (RIGHT); SYGMA (TOP)

weapons states, and the increasing danger of mistaken, accidental, or unauthorized nuclear launch." Echoing Niels Bohr, Nunn emphasized that the world can successfully address such threats only through cooperation. The alternative is unthinkable.

"I'm not sure we fully grasp the devastating, world-changing impact of a nuclear attack," Nunn said. "If a ten-kiloton nuclear device goes off in midtown Manhattan on a typical workday, it could kill more than half a million people. Ten kilotons, a plausible yield for a crude terrorist weapon, has the power of 10,000 tons of TNT. To haul that volume of explosives, you would need a cargo train 100 cars long. But if it were a nuclear bomb, it could easily fit into the back of a truck. Beyond the immediate deaths and the lives that would be shortened by radioactive fallout, the casualty list would also include civil liberties, privacy, and the world economy."

Niels Bohr and Robert Oppenheimer would recognize our dilemma: What to do with the double-edged sword they handed us, forged from exotic metals by a nuclear reaction that science stumbled across one day in 1938 while going about its business of discovering how the world works. Their advice, I think, still holds: Only cooperation among nations can secure the deadly metals from which nuclear weapons are made. Only negotiated reductions in arsenals and limitations on weapons development can diminish the long-term risk to us all. That's what Bohr and Oppenheimer fervently believed, and what Oppenheimer told the scientists of Los Alamos that rainy night 60 years ago. □

**MUSHROOM CLOUD** See video of the 1946 nuclear test at Bikini Atoll, pictured on pages 98-9 of our story, and then read Field Notes from Pulitzer Prize-winning author Richard Rhodes at [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508).

**AGAINST NUCLEAR ATTACK, NONE HAS BEEN FOUND.**



# 65760 NOT QUITE Utopia







**Welcome to East Wind, a 75-member commune in the Ozarks, where the vegetables are fresh, the behavior is bohemian, and gardening in the nude is provocative only to outsiders. “It was a pretty day, and I was with my new lover,” explains Rachael. “Why not?”**

**BY ALAN MAIRSON**  
ASSISTANT EDITOR

**PHOTOGRAPHS BY  
MARIA STENZEL**





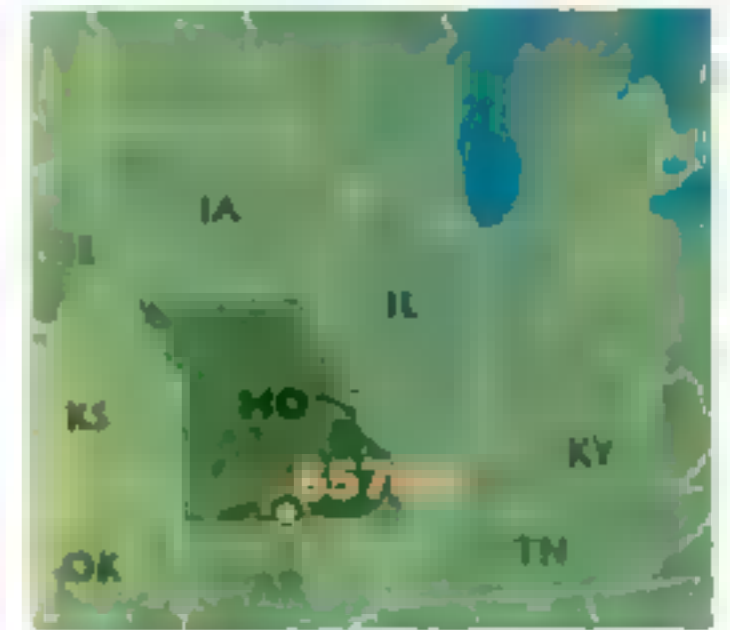
**If most meetings at the East Wind commune typically draw about 10 people, why did more than 50 come out of the woodwork for this one?**

“Well,” says Kara Jo, an East Wind resident for nine years, “people always show up for a lynching.” She’s kidding (mostly). Yet when a majority of the commune’s 75 free-spirited residents appear in one place at one time, something clearly is at stake: Yarrow, 26, has been getting drunk again. He’s failing to meet his labor quota; he’s smashed up a communal car; and he’s ticking people off. After posting complaints on the bulletin board, members scheduled a meeting to find a cure for this chronic pain.

Every community has its problems, of course, but it’s hard to visit East Wind without high expectations. Nestled in the Ozark Mountains on 1,000 acres of land, this commune bills itself as an “intentional community” that strives to be egalitarian, noncompetitive, nonviolent, and “an ally of our bioregion and planet.” Members use first names only—often ones they’ve made up, like Pilgrim and Simple. They eat organic fruits and vegetables from their garden, where some labor in the nude. And they run a business making nut butters—peanut, almond, cashew, macadamia—that annually generates \$500,000 in profits. The money is pooled and pays for everything the residents share, including food, clothing, child care, and transportation. If this sounds like hippie heaven, East Winders are quick to set you straight: This is not utopia.

The fact that a capitalist enterprise is supporting a socialist commune is an irony not lost on East Wind’s founders. “We thought we were going to change the world,” says Deborah, 56, one of a group of friends who left Boston in 1973 to create East Wind. Back then it was still possible to believe a socialist revolution was sweeping the globe. “The east wind is prevailing over the west wind,” said Mao Zedong in 1957, when he was chairman of the People’s Republic of China. His vision of socialism blowing away capitalism gave East Wind its name and helped inspire its mission: To create a place where people get what they need, give what they can, and don’t obsess over accumulating stuff.

Sitting on the front porch of Rock Bottom—the



**What creates community at East Wind? Everything from member meetings (above) to a very profitable nut-butter business to a willingness to share food, clothing, housing, money, and even a spot to tuck a toothbrush (below). “My mom thinks this is a cult and wonders why I don’t want anything,” says Tao, 38, one of East Wind’s newest members. “But I do: I don’t want anything to change.”**





## TECUMSEH, MISSOURI

commune's kitchen, dining room, pool hall, poker parlor, and 24-hour hangout—Deborah sips a glass of merlot, rolls yet another cigarette, and ponders what went wrong. “We thought we had the numbers,” she says, “people ready to join us in the belly of the beast.” Amused by the image, two young women sitting nearby curl their fingers, bare their teeth, roar like wild animals—then burst out laughing.

“We failed,” says Deborah, lamenting the demise of the counterculture. East Winders, though, keep on going. Seeking a healthier, happier lifestyle, they still wrestle with familiar problems. The freedom to do your own thing, for instance, can eat away at group solidarity. Apart from two hours a week of required kitchen tasks, members are free to round out their 40-hour work quotas as they choose—gardening, doing laundry, making nut butter. “We’ve organized the nut-butter business so all we do is insert labor,” says Woody, 46, one of the managers. “The problem is how to get people to care about what we’re doing.” Several members feel trapped. Despite years of work for the community, many feel they don’t have enough money or equity to begin a new life elsewhere. Beer, wine, and cigarettes provide welcome diversions for some. “We talk a lot about ideals,” says Lynn, “but by the next morning no one can remember what we said.”

Despite these difficulties, East Wind retains a countercultural allure, attracting a handful of new members each year. They come because they’re sick of life “out there”—the time-sucking commutes, endless bills, and a culture where greasy take-out passes as dinner. Some seek security—three meals a day, clean clothes and a warm bed, health insurance and dental care. Others come to make new friends, to dance and dream, drink and party, have sex and fall in love. All in the comfort of knowing that if they start drinking themselves sick, 50 people might come together on a Sunday afternoon to help them wrestle with their demons.

Arriving at a high-ceilinged workshop to discuss the fate of Yarrow, people sit on the floor or climb into the loft, its graffiti conveying decades of hippie wit and wisdom. (“Even if you win the race, you’re still a rat.”) For three hours the discussion focuses on whether Yarrow should be asked to leave, reflecting the conflicting intentions for this intentional community. “We’re not



**East Wind doesn't work unless everyone pitches in (top to bottom): Barry launders “commie cloz”—shared shirts, pants, lingerie, and more; Cara jars fresh peanut butter for shipment; Otto squeezes wheatgrass juice to drink; Linda gives a friend a bit of Reiki therapy after a tense community meeting.**



## TECUMSEH, MISSOURI

a family, but we are a pseudo-family,” says Kara Jo, 26, who came to East Wind when she was 17. “When people here are at a loss, we help them out. And I don’t want Yarrow to leave.” She turns to Yarrow, who sits slumped in the corner, poker-faced. “You can come hang out with me,” she tells him.

Bad idea, say others. Yarrow needs professional help, and East Wind isn’t a detox center. Some argue for a contract that would specify how Yarrow’s behavior must change. That’s redundant, comes the rebuttal; membership here is the contract. Another member insists that Yarrow will change only when the culture that enables excessive drinking is transformed.

The next day ballots go out, and a week later the verdict is in: Yarrow can stay if he signs a social contract. He does, and promises to change, but soon breaks his vow. Six months later, he’s gone. His exit solves one problem, but it skirts a much larger one: With socialism faltering around the globe, what gives East Winders a sense of hope and keeps them together—besides the peanut butter?

For many it’s the land itself, a back-to-nature, almost neo-pagan faith in Mother Earth. May 1—socialism’s day of solidarity—is Land Day at the commune, with dancing in circles around a maypole. Celebrations—the summer and winter solstices, the equinoxes in fall and spring—are pegged to the cycles of nature, not to any redemptive winds of history. Time, like the seasons, goes in circles, serving up what’s familiar instead of something new. Tomorrow promises to be just another today.

On a chilly Wednesday night someone builds a bonfire on the crest of the hill just outside the music room. Drawn to the blaze, a dozen men and women pound on drums with a mesmerizing beat. As the flames light up their faces and sparks flit like fireflies into the darkness, the hours slowly disappear—and so does the beer. After a while the drumming peters out, then stops. Someone asks what time it is. But no one is wearing a watch. □



Barry and his daughter, Saoirse, ■■■ slowly adapting to ■ new arrangement: Rachael—his ex-lover and Saoirse’s mother—recently paired off ■■■ another man. “I used ■ tell people how to deal with this sort of thing,” says Barry, “but it’s different dealing with ■ yourself.” ■ one goes it alone at ■ weekly drumming circle (below), where the bonfire is warm, the beat primal, and the world “out there” can seem broken beyond repair. “This,” says one member, nodding toward the circle, “is what the end of civilization looks like.”

**WEBSITE EXCLUSIVE** Find more 65760 images, field notes, and resources on intentional communities at [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508).





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Plaintiff alleges that ExxonMobil marketed, advertised, and sold these Lubricant Products as higher performance products, and charged more for them, than products with identical formulations that ExxonMobil sold under a different brand name without informing purchasers that the products were basically identical. There is no claim that the Lubricant Products caused any harm to any vehicles, equipment or property. **ExxonMobil Denies The Claims And Any Wrongdoing.**

**THE SETTLEMENT:** If the Settlement is approved by the Court, ExxonMobil will make available \$6 million for cash payouts; will distribute \$4 million in transferable coupons redeemable on future purchases of Exxon Superflo or Mobil Drive Clean motor oils (or successor products); and will modify how it manufactures, markets, and/or sells its Lubricant Products.

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To exclude yourself from or object to the Settlement, you must send a request for exclusion or your objection to each of the following, postmarked on or before **August 13, 2005**, or **August 8, 2005**, respectively: Michael A. Havard, Provost Umphrey L.L.P., 490 Park Street, P.O. Box 4905, Beaumont, TX 77704 (Class Counsel); and Stephen J. Harburg and Patrick R. Rizzi, O'Melveny & Myers LLP, 1625 Eye Street, N.W., Washington, D.C. 20006 (Counsel for Defendant). Any objection must also be received by the Court at the address listed below by **August 13, 2005**.

To obtain further detailed information about the Settlement, how to exclude yourself or object to it, and a Claim Form, call toll free 1-800-251-9830, log onto [www.lubricantsettlement.com](http://www.lubricantsettlement.com), or write to Lubricant Products Class Action Settlement, c/o The Garden City Group, Inc., P.O. Box #6283, Merrick, New York, 11566-9000.

The Settlement hearing will take place **September 15, 2005**, at 9:00 a.m., at the United States District Court for the Southern District of Illinois, Melvin Price Federal Courthouse, 750 Missouri Avenue, Courtroom 5, East St. Louis, Illinois 62201.

**Please Do Not Contact The Court Or The Clerk Of The Court Concerning This Notice.**

Dated: April 20, 2005

By Order of the Court  
The Honorable Donald G. Wilkerson  
Magistrate Judge  
UNITED STATES DISTRICT COURT FOR  
THE SOUTHERN DISTRICT OF ILLINOIS



# Final Edit



GRAULICH. PALM POST/ZUMA PRESS

IN HOT WATER

## Sour Harvest

An incoming hurricane might at first seem a powerful photo subject. But how is a photojournalist to make a decent still image when it's dark outside, when people are hiding, and when the main subjects are howling wind and spraying water? "That's why hurricane photography generally documents the aftermath," says illustrations editor Kurt Mutchler. Downed trees and building rubble are mainstays of the genre.

But this image of green grapefruits blown off branches in a Florida citrus grove was different enough to catch Mutchler's eye. It also explains a shortage at his neighborhood grocery store: "This is why I couldn't find much produce from Florida a few weeks later," he says. "This photo illustrates the long economic reach of a hurricane, and it's one I wish we'd had room for in the article."

**E-GREET A FRIEND** with this image and  the runner-up for Final Edit at [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508).





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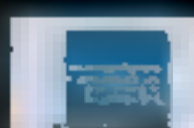
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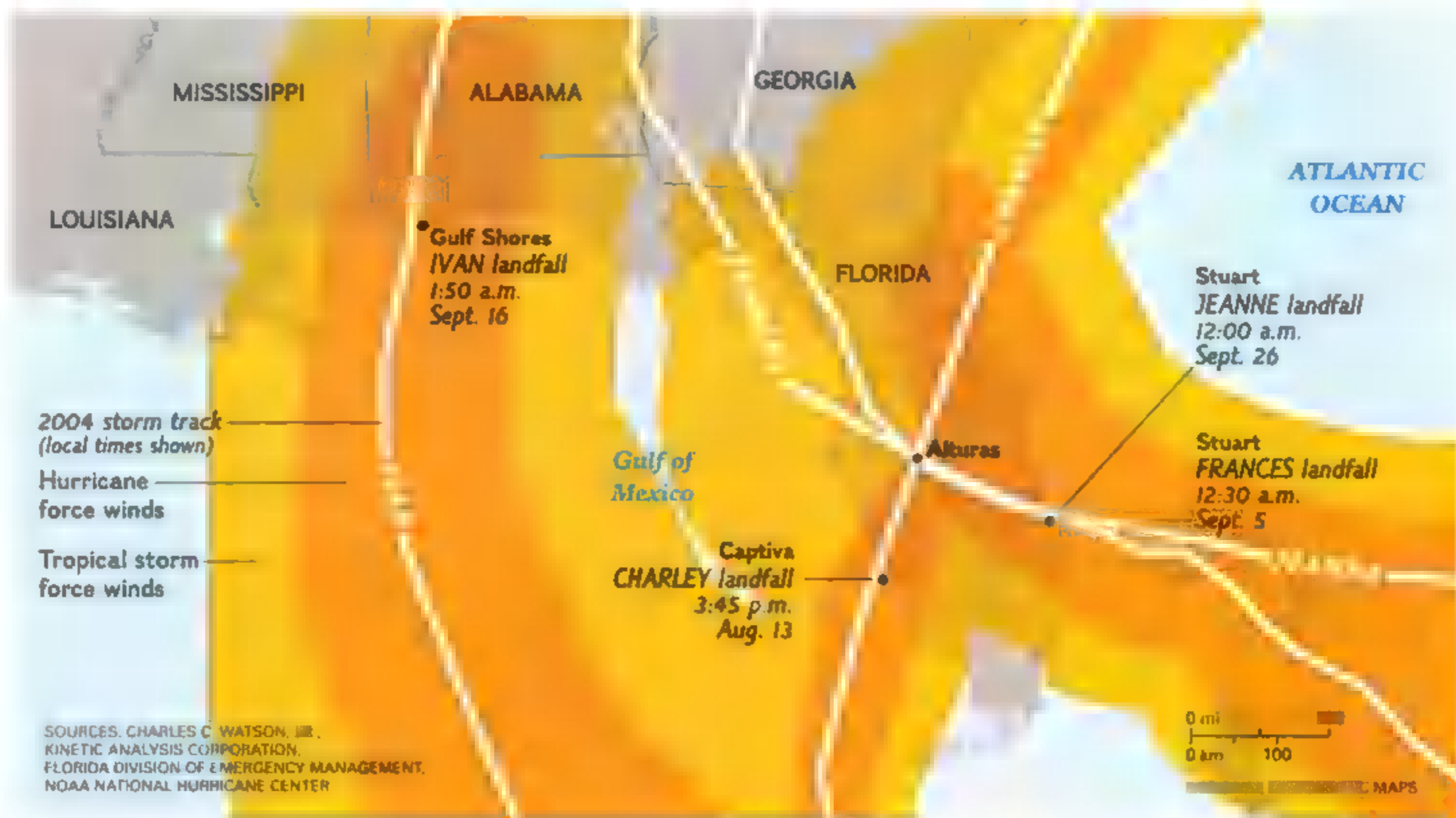


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# Do It Yourself

## HURRICANE WARNING (SEE PAGE 72)



### GET INVOLVED

## Storm Spotting

Floridians are all too familiar with the names Charley, Frances, Ivan, and Jeanne. The four storms swept through Florida last year, devastating property and lives (map). But you don't have to live in Florida to feel the effects of bad weather or to appreciate its power. About 10,000 severe storms, 5,000 floods, and more than 1,000 tornadoes hit the U.S. each year.

Skywarn, a nationwide program run through the National Weather Service, teaches volunteers how to identify cloud formations, wind gusts, and other atmospheric conditions that signal dangerous weather. These volunteers become essential eyes and ears in the field for the National Weather Service and report their observations to local forecasting stations.

To find out how to become a storm spotter go to [nws.noaa.gov/skywarn](http://nws.noaa.gov/skywarn).

## Go to Extremes

Have a yen for an intense vacation? Check out these record-breaking spots—where even golf can be extreme sport.

**Hottest** Dalol, Danakil Depression, Ethiopia; average temperature 93.2°F

**Wettest** Mawsynram, in India's Himalayan foothills; average annual rainfall 467 inches

**Driest** Atacama Desert, Chile (left); average annual rainfall less than one inch

**Coldest** Sovietskaya, Antarctica; average temperature minus 71°F

**Windiest** Mount Washington, New Hampshire; annual average wind speed is 35 miles an hour, but the fastest wind ever measured, 230 mph, was recorded here in 1934.

TOURISTS PLAYING GOLF IN THE ATACAMA DESERT, CHILE

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### ONLINE HURRICANES Tour

an online photo gallery, in Features at [nationalgeographic.com/magazine/0508](http://nationalgeographic.com/magazine/0508)





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# Flashback



FORD MOTOR COMPANY

## FUTURE POWER

### Drawing on the Future

Its driver may have been a dummy, but this model of the Ford Syrtis looked smart in 1953—when gas prices hovered at 29 cents a gallon. Sketched here by a designer from the company's Advanced Styling Studio, it boasted high-intensity headlights that beamed through fender peepholes. Though never manufactured, the Syrtis served as a concept car for Ford's 1957 Skyliner Hide-Away Hardtop. That auto's steel roof lifted with the push of a button and folded itself—in a minute-long mechanical ballet—neatly into the trunk.

—Margaret G. Zackowitz

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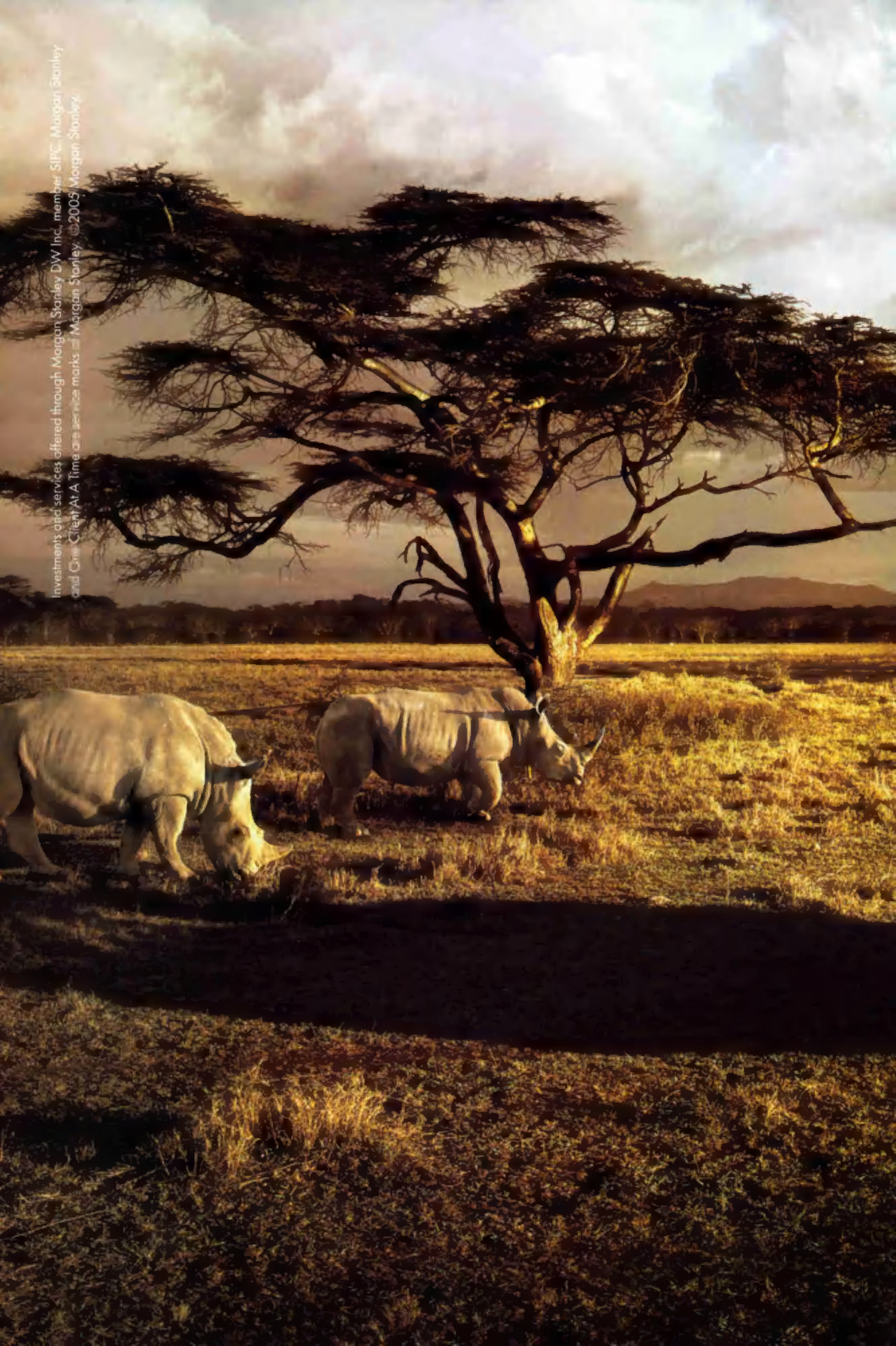
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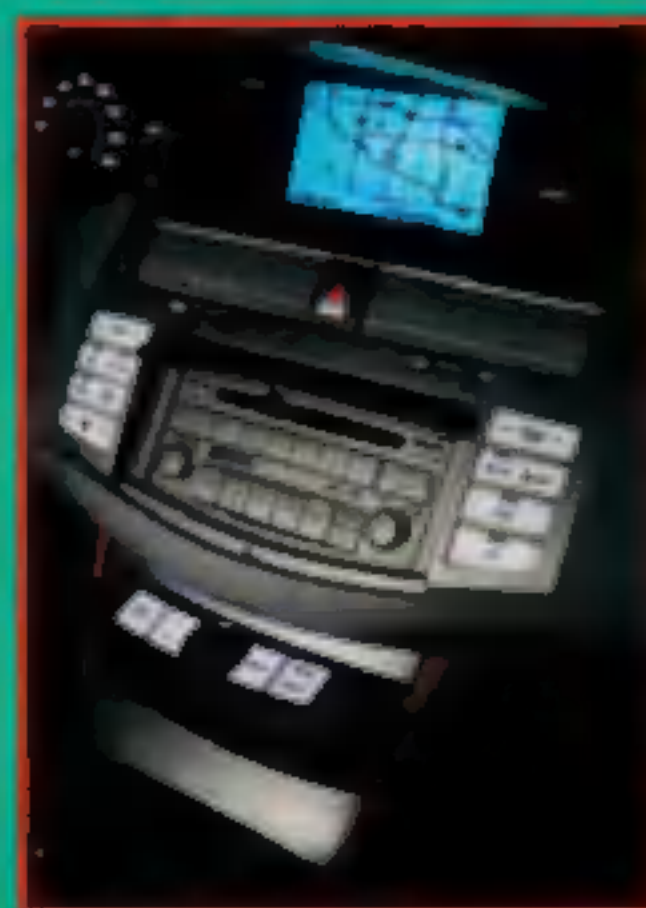
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